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AN ESSAY

TOWARDS A

SYSTEM OF MINERALOGY.

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TRANSLATED FROM THE ORIGINAL SWEDISH,

WITH ANNOTATIONS, AND AN ADDITIONAL TREATISE ON THE BLOW-PIPE.

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39819

THE SECOND EDITION,

GREATLY ENLARGED AND IMPROVED, BY THE ADDITION OF THE MODERN DISCOVERIES; AND BY A NEW ARRANGEMENT OF THE ARTICLES

BY JOHN HYACINTH DE MAGELLAN,

LUSITANO-BRITANNUS, ET REG. SOC. LONDIN. ACADEMIARUM IMP. SCIENTIAR. PETROPOLIT. ET BRUXELL. REG. ULISIPON. MADRIT. ET BEROLI. SOCIET. PHILOS. PHILADEL. HARL. ET MANCHEST. SOCIUS; ET ACAD. REG. PARIS. SCIENTIAR. CORRESPONDENS.

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CLASS III.

Mineral Inflammable Subſtances.

SECT. 228. (144.)

Inflammables. *Phlogiſta Mineralia* [a].

TO this claſs belong all thoſe ſubterraneous bodies that are diſſoluble in oils, but not in water, which they repel; catch flame in the fire; and are electrical.

It

[a] Under the claſs of inflammables, are comprized all ſuch minerals as may be deſtroyed by combuſtion, upon the application of a ſtrong heat; and which, in proper circumſtances, emit flame, during the time of combuſtion. *Sulphureous metallic ores*, *pyrites*, and even *metallic ſubſtances*, may be conſidered as an order belonging to this claſs, although they require a ſtill higher degree of heat, to drive off their phlogiſton. The *diamond* and *plumbago* ſeem to be alſo in the ſame caſe. This arrangement, however, would occaſion that confuſion which is meant to be avoided, by the ſyſtematic claſſification given by our Author in Sect. 2. In regard to theſe two laſt ſubſtances, I have retained the *Diamond* among the precious ſtones; and the *Plumbago* follow the Sulphurs in the preſent Claſs. The Molybdena

It is difficult to determine, what conſtitutes the difference between the purer ſorts of this claſs;

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lybdena however, that has been reputed formerly as a ſpecies of *plumbago*, later experiments have ſhewn to be of a metallic nature: and of courſe, it will be ranged in the laſt Claſs, after the Semi-metals.

The Noble Author ſays, that phlogiſtic ſubſtances are *electric (perſe)*. It has not, however, that I know, been decided, that all *inflamable minerals* are *electric*, or *non-conductors* of electricity; on the contrary Mr. Kirwan affirms, that foſſil coal is not an *electric*.

But, what is the conſtituent principle by which the minerals, belonging to this Claſs, become *inflamable*? or rather, what is the nature of theſe *combuſtible ſubſtances*? what is *combuſtion*, this common phenomenon ſo repeatedly beheld, and ſo little underſtood, from whence theſe ſubſtances take their denomination? Chemiſts and Philoſophers have given various, and ſo ſeemingly oppoſite theories on this very intereſting ſubject, that it would be impardonable not to give a ſhort account of their ideas, chiefly thoſe of the modern ones, in this edition of a work, whoſe matter is ſo intimately connected with theſe chemical diſquiſitions.

It was taught by former chemiſts, that the integrant parts of *combuſtible bodies* were only *heated*, *burned*, and *reduced into flame*, by the action of *fire*, according to the quantity and condition of the *phlogiſton* they contained. This laſt is what they called the *inflammable principle*, by means of which *combuſtion* is performed. But Becher, Boyle, Rey, and ſeveral other Chemiſts, admitted that the concourſe of *air* is abſolutely neceſſary for the effect of *combuſtion*. As ſoon as the various kinds of aeriform-ſubſtances began to be known by Modern Philoſophers, they ſoon found, that it is that *kind of air*, diſcovered by the Father of this new and valuable branch of Natural Philoſophy, Dr. Prieſtley, which he calls *dephlogiſticated*, and to which ſome new Nomenclators give the epithets of *pure*, *vital*, *air of fire* and *empyreal air*, without the interference of which no combuſtion can take place. It is computed,

claſs; ſince they all muſt be tried by fire, in which they all yield the ſame product; but thoſe

puted, from many good obſervations, that among the various component parts of the atmoſphere, there is about one-fourth ($\frac{1}{4}$ according to Scheele), or, at leaſt, one-fifth part (according to Mr. Cavendiſh) of this kind of air, contained therein; and from this circumſtance it evidently appears, why by blowing on fire, its violence is proportionably increaſed.

Mr. Macquer ſays poſitively, that *phlogiſton* is nothing elſe but the *elementary fire, combined with combuſtible bodies*; and that the concurrence of *pure air* is abſolutely required, for the effect of *combuſtion*. The manner, however, by which this wonderful, though common, proceſs is really performed, has been the theme of various modern ſyſtems.

According to Mr. Lavoiſier, *dephlogiſticated air* is a *compound* of two ſubſtances intimately combined; one is called by him *oxygine principle*, and the other is the *ſpecific elementary fire*. When *ſulphur*, *phoſphorus*, *inflammable air*, or any other *combuſtible* body is burned, the *oxygine principle* of the *dephlogiſticated* air, ſays he, combines itſelf with theſe bodies, to which it has a ſtrong attraction, and forms new compounds of ſalts and other bodies (See the latter part of note *a* to Sect. 227): At the ſame time that the *elementary fire* contained in that air, is ſet looſe, and becomes *ſenſible*, producing *heat* and *flame*, according to circumſtances. In this ethiology the fire produced in *Combuſtion* does not proceed from the burned body, but from the decompoſition of the *dephlogiſticated air*, in which it is contained in a *latent* or *inſenſible ſtate*; while its *oxygine* principle combines itſelf with *ſulphur*, *phoſphorus*, or *inflammable air*; and forms *vitriolic* and *phoſphoric acids*, or *pure water*.

In the ſame manner it is pretended, in this theory: 1ſt, That metals are merely ſimple ſubſtances; 2dly, That *metallic calces* are true compounds formed by the *oxygine* part of *pure air*, with the metallic particles; and 3dly, that *pure water* is a ſimilar *compound* of the ſame *principle*, with *inflammable air*. Unhappily, however, it happens that this *oxygine* ſubſtance cannot be ſhewn to our ſenſes: nor is it better

thoſe which in the fire ſhew their differences by affording

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demonſtrated, than the *phlogiſton* ſuppoſed by the great Stahl and his followers. Mr. Fourcroy has propoſed another ſyſtem after Mr. Lavoiſier, which ſeems leſs objectionable: he ſays, that *combuſtible bodies* are thoſe, which have a ſtrong attraction to unite or *combine* with *pure* or *dephlogiſticated* air; and that *combuſtion* is nothing elſe but the act of that combination. This aſſertion is grounded on the following facts: 1ſt, That a body cannot be burnt without *air*: 2dly, That the purer is this *air*, the more rapid is the *combuſtion*: 3dly, That in *combuſtion*, an abſorption or waſte of *air* is always obſerved; and 4thly, That the reſiduum contains often a very ſenſible quantity of that *pure air*, which it abſorbed, and which may ſometimes be extracted from it. According to this theory of *combuſtion*, the objections againſt the exiſtence of phlogiſton, which indeed cannot be demonſtrated by an immediate indication to our ſenſes, are intirely avoided. But there are ſo many phenomena in mineralogy, chemiſtry, and natural philoſophy, which cannot be well underſtood, nor properly accounted for, without admitting *phlogiſton* as a ſubſtance, to the preſence or abſence of which they are adequately attributed, that the *phlogiſtic principle* cannot be exploded, with propriety, from the theoretic part of Chemiſtry. *See the note to the following Section about the exiſtence of* Phlogiſton.

Long before Meſſieurs Lavoiſier and Fourcroy communicated their doctrine of *combuſtion* to the public, the *Treatiſe* of Mr. Scheele on *fire* was publiſhed, in 1777, at Stockholm, in which this great Chemiſt diſcloſes his new ſyſtem on *fire*, *heat*, *light*, and *phlogiſton*; theſe he repreſents, in ſuch a ſtriking manner, as being different ſubſtances, though nearly related to one another, that we ſhould hardly refuſe our conviction to his inductions, were they generally ſupported by facts, and more conſonant to our former ideas on a ſubject ſo little perceivable by our ſenſes. *Heat*, according to this able Chemiſt, is a *compound ſubſtance*, conſiſting of *phlogiſton* and *empyreal air*. The calces of gold, which can be reduced to a metallic form, by *heat* alone, in a retort, ſhew that *phlogiſton* is contained in *heat*: becauſe it combines with the *calces* to

revive

fording different ſubſtances, are here conſidered as being

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revive them, and the *dephlogiſticated* air is found in the receiver. The precipitate *per ſe* of Mercury, if revived in the ſame manner, gives another inſtance of this truth. If phlogiſton alone, ſays he, could paſs through the retort, there would not be found the *empyreal air* in the receiver, and the ignoble metals might be alſo revived in the ſame manner.

I do not ſee, I muſt confeſs, that Mr. Scheele has pointed out any reaſon, why the *ignoble metals* ſhould not be reduced or revived likewiſe, from their calces, by the *phlogiſton*, contained in the *heat* that paſſes through the retort; and as to the *dephlogiſticated air* he ſpeaks of, which is found after the reduction of thoſe *noble metals*, it may have been combined with their calces, before they were put into the retort. Mr. Kirwan, in his Notes to this *Treatiſe on Fire*, from which this ſummary view is taken, ſays, 1ſt, that in no inſtance does it appear that phlogiſton penetrates through glaſs, much leſs a compound of *pure air* and *phlogiſton*; and 2dly, that if Mr. Scheele's notions were true, then other metallic calces, or at leaſt black manganeſe, would be reduced by bare heat; for this calx dephlogiſticates nitrous acid, and therefore has a ſtronger affinity with *phlogiſton* than this acid, as Bergman affirms: *heat* therefore ought as well to be *decompoſed* by it, as by nitrous acid. This laſt objection can hardly be anſwerable but by ſome unknown property of the manganeſe, which is no anſwer at all. But in regard to the firſt, many combinations are known of two or more ſubſtances that paſs through bodies, which would ſtop each before they were combined; and what Mr. Scheele has ſaid on the nature of *light*, ſeems to prove, that glaſs is not always quite impervious to *phlogiſton*.

Light, according to Scheele, is a compound, containing *phlogiſton* and *heat*, from which both may ſeparate themſelves in proper circumſtances. A ſolution of ſilver, by *nitrous acid*, mixed with *chalk*, and expoſed to the ſun-ſhine, is revived into a metallic form by the phlogiſton of *light*. Nitrous acid alſo in a glaſs veſſel, receives *phlogiſton* from *light*, and becomes of an orange colour; but if the glaſs be painted black,

being mixed with heterogeneous bodies; that ſmall

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the acid receives the *heat*, not the *phlogiſton*. Even the various coloured rays of light contain unequal ſhares of phlogiſton, ſince the *violet rays* part more eaſily with their *phlogiſton*, than the other rays, to revive metals. When light is not obſtructed in its paſſage, no heat is perceived; but if ſtopped in its courſe, the oppoſing body receives *heat*, and ſometimes *phlogiſton*. Light ſeems therefore to be the matter of *heat* loaded with a ſuperabundant quantity of *phlogiſton*. That which comes out from a furnace, produces *heat* on the ſurrounding bodies, which aſcends up with the rarified air: proceeds forwards in ſtraight lines: and may be reflected from poliſhed ſurfaces, with this peculiarity, that a concave glaſs-mirror retains the *heat*, whilſt it reflects the light; for, although its focus is bright, yet it is not warm. A plane of glaſs interpoſed to this light, retains the heat, and becomes *hot*, but lets the light paſs through.

Fire is the more or leſs *heated*, and more or leſs *luminous* ſtate of bodies, by which they are reſolved into their conſtituent parts, and entirely deſtroyed. It requires that they be previouſly *heated* in contact with air; for, to every *combuſtible body*, a certain quantity of *heat* muſt be communicated, in order to ſet it in the fiery commotion.

Combuſtion is the action of the *heat* penetrating the pores of bodies, and deſtroying their coheſion; in this caſe the body parts with its phlogiſton, provided there be a ſubſtance preſent, which has a ſtrong attraction to the inflammable principle. If the heating be performed in open air, the empyreal air (which makes one-fourth part of the bulk of the atmoſphere), on account of its ſtronger attraction, unites with the *inflammable principle*, which is thus ſet at liberty; from this union the *heat* is compounded; and ſcarcely is this heat generated, when the combuſtible body is ſtill more expanded by it than in the beginning, and its phlogiſton more laid open. The more the heat is increaſed, the more minute are the particles into which the *combuſtible body* is diſſolved. The *empyreal* air meets more ſurfaces, conſequently comes in contact with more *phlogiſton*; and, according to its nature,

ſmall quantity of earthy ſubſtance, which all phlogiſta

ture, forms an union with a greator quantity of it, which cauſes a radiant heat. At this moment the conſtituent parts of the combuſtible body are ſo much diſunited by the ſtill increaſing heat, that the empyreal air, continuing to pour upon it in ſtreams, attracts the phlogiſton in ſtill greater quantities; and hence the moſt elaſtic ſubſtance, *Light*, is compoſed, which, according to the quantity of *combuſtible matters*, ſhows various colours.

Such is the abſtract of Scheele's new ſyſtem, taken from that given by Mr. Ruſſel, in his Notes to *Fourcroy's Lectures* of Chemiſtry, which I compared with the original French tranſlation of the Author, as it is more correct than the Engliſh tranſlation of J. R. Foſter; and it appeared to me perfectly conſonant to the author's ideas. But the only ſyſtem that I know, which fully and ſatisfactorily developes theſe obſtruſe matters, relating to the nature of *combuſtible* and *phlogiſtic proceſſes*, is that given to the public by Dr. Adair Crawford, whoſe friendſhip I ſhall always acknowledge with the higheſt pleaſure. His New Theory was compleated, and put in the hands of the public, before either he, or any other perſon in England, had the leaſt knowledge of Mr. Scheele's doctrine. I publiſhed, in the year 1780, a *ſmall eſſay* on this ſubject, containing a ſketch of Dr. Crawford's doctrine, reduced into a mathematical form, which is mentioned by the late famous Profeſſor Bergman, in his excellent treatiſe *de Attractionibus electivis*, and was inſerted in *Journal de Phyſique*, for *May* and *June*, 1781. The following ſketch of the part relating to *combuſtibles*, is the only one that can be allowed to this note.

Dr. Crawford diſcovered, by the moſt accurate and nice experiments, that bodies, which contain a large portion of *phlogiſton*, poſſeſs but a ſmall ſhare of *ſpecific heat* or *fire*; on the contrary, that thoſe with a great ſhare of this laſt, contain but little *phlogiſton*; and finally, thoſe which are deprived of *phlogiſton*, increaſe their capacity for a greater ſhare of *ſpecific fire*. Thus, when regulus of antimony is deprived of its phlogiſton, by calcination, which is then called *diapho-*

phlogiſta leave behind in the fire, is not, however, attended to.

SECT.

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retic, it nearly triples its *ſpecific fire*. The ſame change takes place in the *crocus martis* and in *iron*. This fact is generally true, whatever be the nature of the ſubſtance; and even the aeriform ones are in the ſame caſe; for phlogiſticated air has very little *ſpecific fire*: *common air* has more of *it*; and *dephlogiſticated* air ſhews a moſt prodigious quantity of *fire*.

From theſe facts it is clear, that *phlogiſton* and *fire* are diſtinct and incompatible ſubſtances; ſo that when one enters into the compoſition of any body, the other of courſe is expelled from it. Thus metals are calcined in conſequence of a double attraction, by which the metal imparts its phlogiſton to the air, while the air communicates its fire to the metallic calces; which is further confirmed by the *air* that is found in metallic calces, whoſe increaſed weight, by calcination, correſponds to the *air*, that is expelled from them, by their reduction to a metallic form.

All *combuſtible* bodies are abſolutely in the ſame caſe. Theſe are ſubſtances which contain a large quantity of *phlogiſton* in their compoſition, but looſely adherent to them. *Dephlogiſticated air*, which is greatly loaded with *ſpecific fire*, has, at the ſame time, a ſtrong attraction to *phlogiſton*; and, in the act of *combuſtion*, imparts its fire to the *combuſtible body*, which is conſumed, whilſt the air becomes phlogiſticated, or loaded with *phlogiſton*. Thus we find that ſulphur contaminates the air, when burned, by the *phlogiſton* it throws into it, and the produced vitriolic acid, if any, becomes impregnated with the ſame.

In ſome caſes the moſt intenſe heat, or ſenſible fire, is produced in the combuſtion; but in others it is very moderate. This variety generally depends from the quantity and quality of the vapours produced by the combuſtion; when theſe are very inconſiderable, and the reſiduum cannot abſorb the *fire*, which is emitted by the air, the remainder is precipitated or diffuſed all around, and produces a very ſenſible heat. On the contrary, if the vapours are capable of abſorbing it, then very little heat is produced. We know by the moſt certain

SECT. 229. (Additional.)

Inflammable Air. Fire Damp. *Aer Inflammabilis.*

This aeriform ſubſtance is eaſily known by its property of inflaming, when mixed with twice or thrice its bulk of common atmoſpheric air; and it may be ſafely aſſerted to be the real phlogiſton almoſt pure [*a*].

It

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tain experiments, that, for inſtance, the vapour of water abſorbs about 800 degrees of heat beyond that of its boiling ſtate; from whence it follows, that whenever there is a quantity of watery vapours produced by *combuſtion*, very little *Senſible fire* muſt be felt. So when ſpirits of wine are fired, the ſenſible heat, which reſults from the *combuſtion*, is very inconſiderable, as the greateſt part is abſorbed by the watery vapours that are then produced; but when the phoſphorus of kunkel catches fire, the heat is very ſtrong, there being but a ſmall quantity of acid to carry off the *ſpecific fire* that is ſet looſe. This is the moſt ſatisfactory theory of the nature and proceſs of *combuſtible* bodies, and of their *combuſtion*; ſo far as the ſtate of our preſent knowledge has opened the field of our views into the Operations of Nature. *The Editor.*

[*a*] The late eminent Philoſopher, Profeſſor Bergman, ſpeaking of *phlogiſton*, in his admirable Treatiſe upon Elective Attractions, ſays, that "the *inflammable air* extracted from metals, contains *phlogiſton* almoſt pure; and that the two celebrated Philoſophers, Prieſtley and Kirwan, ſeem to have clearly proved the exiſtence of *phlogiſton*, both analytically and ſynthetically: ſo that, according to him (this laſt named gentleman), all reaſons for doubting are now removed. This phlogiſtic principle, when in combination, may be let looſe by various methods: having recovered its elaſticity, and gained an aerial form, by a proper addition of ſpecific heat,

it

It is naturally found in ſubterraneous cavities, in ſome coal-pits, and other mines; in ſtagnant waters, in the mud of lakes [*b*], and other

it receives the name of *inflammable air*." But ſome French Philoſophers, at the head of whom is the famous Mr. Lavoiſier, pretend, that there does not exiſt ſuch a being in Nature, as that called, ſince the time of Becher and Stahl, by the name of *phlogiſton*.

They ſay that the abſorption, or combination of *dephlogiſticated air*, with metallic bodies, by the help of fire, and its expulſion or ſeparation from their calces by the ſame agent, is all that is required both for their *calcination*, and for their *reduction* or *revification*. But there is a vicious circle in this new theory, which eaſily evinces the fallacy of their argument againſt the exiſtence of phlogiſton. If it be owing to fire, that *pure*, or *dephlogiſticated air*, combines with metals to reduce them to the ſtate of *calces*, why do all metallic calces (thoſe of *gold* and *mercury* excepted) require any *phlogiſtic* or *inflammable ſubſtance* to reduce them back to their metallic form? If not, it ſhould naturally follow that the ſimple expulſion of pure air by fire, without any phlogiſtic matter being made uſe of, ought to be fully ſufficient to effect that revification. Monſieur de la Metherie, in a letter inſerted in the latter part of the *Journal de Phyſique*, for June 1784, p. 473, has produced various and ſtrong reaſons againſt theſe new, but feeble, attempts for exploding the exiſtence of Phlogiſton; and Mr. Kirwan is now collecting the moſt convincing facts to ſet this truth in the moſt clear light. *See what has been ſaid in the Note to the laſt* Sect. *on this ſubject.*

The Editor.

[*b*] Mr. Volta, profeſſor in the Univerſity at Pavia, has diſcovered a kind of *inflammable* air, which is very common in Nature, and is found in the mud of various ponds and rivulets. When a ſtick is thruſt into the mud of ſuch places, the air ruſhes up in large bubbles; and may be eaſily collected by a funnel, held faſt by a metallic ring, into the mouth of an inverted glaſs veſſel filled with water, at the end of a ſtick; in the ſame manner as Dr. Pearſon has propoſed to get the medicinal gas of the Buxton water. This kind of inflammable air

ſeems

other places, where animal and vegetable ſubſtances have undergone putrefaction, as layſtals, old privies, &c. Alſo on the ſurface of ſprings in Perſia, Italy, and France, where it ſeems to be nothing elſe but the exhalation of petrol.

It is found likewiſe over the ſurface of the earth in various places. The *ignis fatuus*, or *jack-lanthorns*, as well as different fiery meteors, owe their exiſtence to this ſubſtance; and the *falling ſtars* ſeem to be nothing elſe but ſo many trains of inflammable air, in the ſuperior parts of the atmoſphere, which catching fire by electricity or otherwiſe, produce that appearance by burning downwards; as is rendered very probable, by the hiſſing noiſe that is ſometimes very audible at their appearance.

Inflammable air is alſo artificially produced in great abundance, by the diſſolution of *iron* or *zinc*, in almoſt all known acids (the *nitrous* excepted); by digeſting iron in an infuſion of galls; by diſſolving zinc in the mineral alkali; by combining iron and zinc with volatil alkali; by the calcination of theſe two metallic ſub-

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ſeems to be the uſual produce of the putrefaction, and compleat decompoſition of vegetable ſubſtances in water. Its inflammability is greater or more intenſe than that of *inflammable air*, produced from the ſolution of iron or zinc in the *vitriolic* acid; for it requires to be mixed with a larger portion of atmoſpheric air, to produce its greateſt exploſion by the flame of a candle. Dr. Prieſtley mentions this diſcovery of Profeſſor Volta, in his 3d vol. on *various kinds of air*: and Mr. Volta has publiſhed, afterwards, a Treatiſe on this ſubject in Italian, with an account of his diſcovery, &c. *Editor.*

ſtances

ſtances in the fire: and Mr. Kirwan found lately, that an amalgam, made of zinc and mercury, in a cloſe veſſel, after both had been previouſly dried in a ſufficiently ſtrong, and long continued heat, produced a good quantity of *inflammable air*; ſo that the boaſted theory of ſome French philoſophers, who pretend that ſome water is eſſentially neceſſary for the production of *inflammable air*, is evidently falſe [*c*].

Oils,

[*c*] When inflammable air and dephlogiſticated air are burned together, water is found to be the reſiduum, as Mr. Volta, many years ago, found often in the experiments made with his new Eudiometer. Meſſ. Cavendiſh, Lavoiſier, Monge, La Place, and Meuſnier, have aſcertained this fact; and that the weight of this water, ſo produced, is nearly the ſame as that of the two burned airs. But neither of theſe gentlemen ever purified the *inflammable* and *dephlogiſticated* air, from the watery vapours they contain: it is theſe laſt, as it ſeems, which produce that water, they find afterwards.

Mr. Cavendiſh ſays, that *pure* or *dephlogiſticated* air, is water deprived of its phlogiſton; and that *water* is *pure air* united with phlogiſton. But Mr. Watt thinks that water is compoſed of *dephlogiſticated* air, and *phlogiſton*, deprived of great part of its *elementary fire*; and that dephlogiſticated air is *water* united to a great quantity of *elementary fire*, and deprived of its phlogiſton.

Mr. Lavoiſier aſſerts, that water is a combination of *pure* and *inflammable air*; ſo that 8686 parts of the firſt, with 1314 of inflamable air, makes 10,000 of water; and that this *inflamable air* is 12 times lighter than *common air*.

But Mr. de la Metherie holds on the contrary, that the water produced by the combuſtion of theſe two airs, is contained in them both. The experiments of the hygrometer, and the deliqueſcence of ſalts, prove, beyond all doubt, that air contains a conſiderable quantity of water: and we know that the mixture of *pure* and *nitrous* air produces *nitrous acid*, which is as *fluid* as water; ſo that *dephlogiſticated air* evidently contains

Oils, bitumens, and charcoal, diſtilled dry in a retort, or by their digeſtion on the fire; lime, and even powder of pebbles, digeſted in the ſame manner with *marine acid*, or with *marine acid air*, produce alſo this inflammable ſubſtance. Its principal properties are as follow:

1. It is the lighteſt of all aeriform ſubſtances; *viz.* 10, or even more times lighter than common air. Mr. Kirwan collected it very ſlowly over quick-ſilver; and found it then 12 times lighter than atmoſpheric air. On this account, inflammable air has been employed in the new invented aeroſtates, by the help of which various adventurers have performed aerial voyages with ſucceſs. But that inflammable vapour, which is formed from vitriolic air, is heavier than common air.
2. It cannot be inflamed without the concurrence of atmoſpheric air; but when mixed with it, in a due proportion, and ſet on fire, it explodes with a conſiderable noiſe. If the mixture be of *dephlogiſticated air*, a detonation is produced as loud, as the report of a piſtol [*d*]; but mixed, or combined

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tains this fluid in itſelf; and the experiment of Mr. Kirwan, mentioned above in the text, is a demonſtration that there is not need of any water or moiſture for the production of *inflammable air*. The Editor.

[*d*] Inflammable air, on account of its elaſtic nature, and of its levity, expands itſelf over a wide ſpace, and may have every particle contiguous to a ſufficient quantity of the *dephlogiſticated*

combined with *fixt air*, it burns with a blue lambent flame.

3. The flame of a candle, a burning coal, an electric ſpark, and that produced by the ſtroke of a flint, with ſteel, ſets it on fire. From whence it is evident, that the idea of employing this laſt kind of light, in thoſe mines where inflammable air happens to be found, is erroneous; though, as it always occupies the higher part of the ſubterraneous cavities, on account of its levity, it may happen ſometimes to eſcape the action of the fire.

4. When unmixed and pure, it extinguiſhes fire.

5. If breathed, it kills animals. Thoſe who pretended to breathe it with impunity, did not previouſly breathe out, from their lungs, the whole of the common air, that there was before.

6. It has a diſagreeable ſmell, when extracted from metals; if over mercury, the ſmell is better. That which is found in marſhes, ſmells muſty.

7. It is not abſorbed by water, at leaſt that which is extracted from metals, over which it may be kept a long time without alteration; but after one or two years, it is no more inflammable.

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phlogiſticated air mixed with. In this ſituation a ſpark of fire pervades the whole maſs at once, and produces that violent exploſion. *Editor*, *from* Ruſſel's notes.

8. Does

8. Does not render lime-water turbid by itſelf; but being inflamed over it, the water is troubled, and depoſits ſome of the chalk it contains.
9. Has no acid qualities.
10. Does not calcine metals; on the contrary, Dr. Prieſtley has revived ſome of their calces by the rays of the ſun, through a burning lens, in a glaſs veſſel filled with this air, over a baſon of mercury.
11. It accelerates vegetation.
12. It hinders putrefaction, though in a degree very inferior to fixed air.
13. It is abſorbed by charcoal [e].

Editor, chiefly from Leonhardi, Kirwan, &c.

SECT.

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[e] Inflammable air admits conſiderable varieties, according to the nature of the ſubſtances from which it is produced, and often gives different reſiduums upon combuſtion, ſome of which are of the acid kind. If it is produced from charcoal, it yields *aerial acid*, or *fixt air*: from ſolutions of metallic ſubſtances in the *vitriolic*, *nitrous*, or *marine acids*, it yields theſe reſpective acids, as Mr. Lavoiſier aſſerts.

Æther, converted into vapour in a vacuum, gives a permanent elaſtic vapour, which is *inflammable*. The atmoſphere, which floats round the *Fraxinella* (the plant called *dictame blanc*, which grows in the woods of *Languedoc*, *Provence*, *Italy*, &c.) is inflamable from the admixture of its vapours, which ſeem to be of the nature of an eſſential oil: ſo that on approaching the flame of a candle under this plant, in hot weather, it takes fire in an inſtant; although the eſſential oil, extracted from this plant by diſtillation, is not inflamable, on account of the watery particles mixed with it, as Mr. Bomare aſſerts.

Mr. Scheele is of opinion, that every inflammable air is compoſed of a very ſubtile oil. This coincides with the idea entertained

SECT. 230. (Additional.)

Hepatic Air.

This air ſeems to conſiſt of ſulphur, held in ſolution, in vitriolic or marine air. It is inflammable, when mixed with three quarters of its bulk of common air. Nitre will take up about half the bulk of this air: and when ſaturated with it, will turn ſilver black; but if ſtrong dephlogiſticated nitrous acid be dropped into this water, the ſuphur will be precipitated [*a*].

One

entertained, by chymiſts, of their phlogiſton; and is confirmed by the fact, of its being naturally found in thoſe ſprings from whence iſſues petrol, whoſe exhalations are very inflamable.

The reſiduum, which remains in the atmoſphere after the combuſtion of inflammable air, is extremely noxious to animals. Doctor Prieſtley takes it to be a combination of *phlogiſton* with *pure air*, and, on this account, calls it *phlogiſticated air*. But Mr. Lavoiſier, on the contrary, thinks this to be a *primitive ſubſtance* of an unchangeable nature, and gives it the ſingular name of *atmoſpheric mephitis*. The Editor.

[*a*] The great Swediſh Chemiſt Mr. Scheele, was the firſt who diſcovered the exiſtence of this kind of air; and although his Treatiſe on *Air and Fire* has been publiſhed ſince the year 1777, hardly any other philoſopher has carefully examined its ſingular properties. Mr. Kirwan has, however, applied himſelf of late to this object; and has communicated to the Royal Society, his various and intereſting obſervations upon it; as theſe were made on veſſels over quickſilver, we may depend on the reſults, becauſe, if the veſſels are over water, this air is in great part abſorbed by it; and for this circumſtance

One hundred cubic inches of this air, may hold eight grains of ſulphur in ſolution, in the temperature of 60°; and more, if hotter.

Atmoſpheric air alſo decompoſes hepatic air.

It is found in many mineral waters, and particularly in the hot baths of Aix-la-Chapelle.

The

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circumſtance theſe reſults are ſometimes different from thoſe of Mr. Senebier, who has wrote on the ſame ſubject.

Profeſſor Leonhardy, in his Treatiſe upon the *Diſcoveries of various Airs*, points out the moſt part of the following properties of *hepatic air*.

1. Its ſmell diſtinguiſhes it from any other kind of air, being like the ſmell of rotten eggs, or the ſmell of *hepar ſulphuris*.
2. Mixed with two-thirds of common or nitrous air, it may be ſet on fire by the flame of a candle, like the *inflammable air* of the laſt Section; the veſſel is filled with a white thick ſmoke, which ſmells like volatil ſpirit of ſulphur; and a white powder is depoſited, which conſiſts of ſulphur. It detonates with *dephlogiſticated air*.
3. It is miſcible with water, and communicates to it a flat, but penetrating and very diſagreeable flavour.
4. It kills animals, if incloſed therein.
5. It extinguiſhes alſo the flame of a candle when immerſed in it.
6. Does not change the colour of paper tinged with Fernanbuco wood:
7. But it always turns the tincture of turnſol to red, whatever be the manner by which it had been produced.
8. Mixed with atmoſpheric air, it phlogiſticates it.
9. The vitriolic, marine, and acetous acid, do not precipitate the ſulphur from it. But
10. Nitrous acid, and dephlogiſticated marine acid, do precipitate the ſulphur from it.
11. Tin, biſmuth, regulus of antimony, and zinc, are not attacked by this air.

The cauſe and manner of their containing ſulphur, which was long a problem, has at laſt been happily explained by Mr. Bergman.

It plentifully occurs in the neighbourhood of volcanos, and in ſeveral mines. *Kirwan.*

12. But copper and iron become of a blue colour; lead eaſily tarniſhes, when immerſed in it; and mercury becomes black.

13. Water, impregnated with hepatic air, turns ſilver black; precipitates arſenic, from its ſolvent, into a powder reſembling orpigment: precipitates zinc from the vitriolic acid; and the ſolution of corroſive ſublimate, into a white powder. The ſolutions of ſilver in nitrous acid and of ſalt of lead, are precipitated of a black colour. The ſolution of copper, and of the martial vitriol, as well as that of mercury in nitrous acid, are precipitated by the ſame, of a dark brown colour.

14. This water, ſo impregnated, diſſolves iron filings; and this ſolution takes a purple colour, if the infuſion of galls be added to it. But phlogiſticated alkali does not produce any change.

15. It does not precipitate lime from lime-water, unleſs a very large quantity of this air paſſes through a ſmall one of water.

Hepatic air is eaſily obtained by art, from all ſorts of liver of ſulphur, whether the baſe be an alkali, an earth, or a metal, if any acid is poured upon it: and the better, if uſe is made of the marine acid, becauſe it contains phlogiſton enough, and does not ſo ſtrongly attract that of the *hepar ſulphuris*. For this reaſon the nitrous acid is not fit for this proceſs, as it combines itſelf with the phlogiſton, and produces *nitrous air*. It may alſo be produced, by diſtilling a mixture of *ſulphur* and *powdered charcoal*; or of ſulphur and oil, &c.

According to Mr. Kirwan (in the firſt part of *Phil. Tranſ.* for 1786), *hepatic air* conſiſts of *ſulphur* alone, kept in an aerial ſtate by the *matter of heat*. It has evidently, though weakly, an acidity of the *vitriolic kind*, as ſulphur does; and no *inflammable air* can be extracted from it, unleſs when produced by thoſe compounds, which afford the ſame, as *carbonaceous*, and *ſaccharine compounds*, &c. *The Editor.*

SECT.

SECT. 231. (154.)

Phlogiſton combined with Aerial Acid. Black Lead, or *Wadd*. Phlogiſton acido aereo ſatiatum. Plumbago, *Lat.* Reiſbley, *Germ.* Blyertz, *Swed.* [*a*].

..... It is found

b. Of a ſteel-grained and dull texture, *textura chalybea*. It is naturally black; but when rubbed, it gives a dark lead-colour.

c. Of

[*a*] The Author, and all preceding Mineralogiſts, confounded the *black lead* with *molybdena*, whoſe appearance is nearly the ſame; although, on cloſe examination, the texture of the laſt, which is compoſed of very diſtinct oblong ſcales, eaſily diſtinguiſhes it from the *black lead*. This laſt ſubſtance, having been lately found to be of a metallic nature, will be ranged among the *Semi-metals* in the fourth and laſt Claſs of Minerals.

The black-lead, or plumbago, is a foſſil ſubſtance extremely black; but when freſh cut it appears of a bluiſh white, and ſhining as lead.

Its texture is micaceous, and minutely ſcaly; pretty brittle; and, when broken, of a granullar and dull appearance.

It leaves a fine blackiſh, ſmooth, and ſhining trace, when rubbed on paper; but of a much darker hue than that made with molybdene, which has a white ſilvering appearance. This eaſily diſtinguiſhes one from the other.

Black-lead is too ſoft to ſtrike fire with ſteel.

c. Of a fine ſcaly and coarſe-grained texture, *textura micacea et granulata.* Coarſe black-lead.

It has

Its ſpecific gravity is from 1,987 to 2,267. Briſſon found it to be = 2,1456.

Is inſoluble in the mineral acids.

In a ſtrong heat and open fire it is wholly volatile, leaving only a little *iron*, which ſeems to be accidentally found in it, and a few grains of ſiliceous earth.

The uſual fluxes do not effect its fuſion.

It is decompoſed by detonnation with nitre, in a red hot crucible.

Mr Scheele found that plumbago conſiſts of phlogiſton combined with *aerial acid.* But Mr. Pelletier has demonſtrated, that, when it is pure, it neither produces any *fixed* or *inflamable air*; both which, when found, are entirely owing to the ſubſtances that are mixed with it.

One part of *plumbago*, according to Mr. Scheele, requires ten of nitre to decompoſe it, whereas one of *charcoal* requires five of *nitre*; hence it appears to contain twice as much phlogiſton as charcoal does.

From hence Mr. Kirwan deduces, that 100 parts of plumbago contain 67 of phlogiſton; for 100 *gr.* of nitre contain 33 *gr.* of real *nitrous acid*; theſe are decompoſed, when it receives as much phlogiſton as is neceſſary to convert it into *nitrous acid*, or a little more. Now 33 *gr.* of nitrous acid are converted into *nitrous air* by 67 *gr.* of phlogiſton; then 100 *gr.* of nitre require, for their decompoſition, 67 *gr.* of phlogiſton. The remaining 33 *parts* may be water, or other volatile ſubſtance. For, according to Meſſieurs Gahn and Hielm, 100 *gr.* of plumbago, calcined in a muffle, did looſe 90 *gr.* in weight, the remainder was a ferrugineous earth; and the ſulphureous ſmell ſhewed it contained ſome pyrite, which both were accidental to the black-lead. But Mr. Pelletier affirms, that this ſubſtance is volatilized in a ſtrong fire, without producing any air, nor other aeriform ſubſtance; from whence

it

It has at the ſame time a ſcaly and a granulated appearance.

From

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it muſt be concluded, that the plumbago analyſed by Mr. Scheele, was not quite pure.

But when this ſubſtance is expoſed in cloſe veſſels, it undergoes a long and ſtrong heat, as charcoal does, without any loſs in its weight,

Our Author (Cronſtedt), has obſerved, in a note to this Section, that "Profeſſor Pott had examined the black lead "in covered veſſels, and Mr. Quiſt, in an open fire: from "which difference in the method of treating it, different "notions have ariſen: becauſe the black-lead is nearly unal-"terable when expoſed to the fire in covered veſſels, or when "immediately put into a ſtrong charcoal fire, but it is almoſt "wholly volatile in a calcining heat. This is the caſe with "ſeveral others of the mineral phlogiſtons; and from this we "may in general learn, how neceſſary it is to examine the "mineral bodies by many and different methods; and to en-"deavour to multiply the experiments more, than what has "been hitherto done."

Mr. Pelletier aſſerts, that metallic calces cannot be reduced with it alone, unleſs mixed with *fixed alkaly*, in the ſame manner as when charcoal is employed in ſuch circumſtances.

Nor can it be combined with iron, as Bergman aſſerts, or with any other metal, although it may be ſimply interſperſed between its particles.

Mr. Pelletier acknowledges, that there is a kind of plumbago found ſwimming over the melted iron in large furnaces, where iron-ores are ſmelted. But he thinks that this muſt have been naturally mixed with the mineral; and it is the only known plumbago of a very diſtinct lamellar form, as he obſerved in the pieces got from the iron-works at Vallancy, in the French Province of Berry.

This ſingular foſſil was claſſed alſo among the *inflammables* by Profeſſor Bergman, in his *Sciagraphia*, as well as the *diamond*, on account of their burning in a vehement fire, without leaving any reſiduum. Mr. Kirwan, in his excellent *Elements of Mineralogy*, thought they both deſerved

From Gran in the province of Upland, and from Tavaſtehuſlan in Finland [*b*].

SECT.

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deſerved to be treated ſeperately from any other claſs of foſſil ſubſtances, on account of their combuſtion commencing at ſo high a degree of heat; but I thought proper to preſerve them both, in the claſſes where our Author had put them at firſt, as was already mentioned, Note *a*, page 433.

[*b*] Black-lead is found in various parts of the world, though ſparingly, and of very different qualities; viz. in *Germany*, *France*, *Spain*, *Cape of Good Hope*, and *America*; but the beſt ſort, which by its fine black and ſhining ſubſtance, is the fitteſt of all for making good pencils to draw upon paper, is only found in the County of *Cumberland*, in England, at a place called *Borrowdale*, which may be ſaid to furniſh the whole continent abroad, as well as at home, with this uſeful mineral. I have ſeen various ſpecimens from different countries, but their coarſe texture and bad quality, cannot bear any compariſon with that of *Borrowdale*, though it ſometimes, but ſeldom, contains pyritaceous particles of iron, &c. It is but a few years ago that this mine ſeemed to be almoſt exhauſted; but by digging ſome few yards through the ſtrata underneath, according to the advice of an experienced Miner, whoſe opinion had been long unattended to, a very thick and rich vein of the beſt black-lead has been diſcovered, to the great joy of the proprietors, and advantage of the public.

The great uſe of plumbago, is to draw the out-lines and ſketches of any figure on paper, in the moſt eaſy and expeditious manner; and it has the advantage of being taken off at pleaſure, by rubbing it off entirely with a piece of that elaſtic gum or reſinous ſubſtance, which comes chiefly from Brazil, called by the natives *Caout-chouc*, and known in England, (not many years ago, for this uſe) by the name of *Indian-rubber*. See the following Sect. 238. on the elaſtic Petrol.

The plumbago is adapted for this purpoſe, by being cut into thin parallelopipeds, and put in quadrangular grooves made of cypreſs-wood; and a ſlit being glued over, they are worked into ſmall cylinders like quills. This is the true method

SECT. 232. (Additional.)

Mineral tallow. *Sevum minerale. Mumia*, Lat. *Beleſſoon.*

This was found in the ſea on the coaſts of Finland, in the year 1736. Its ſpecific gravity is 0,770; whereas that of tallow is 0,969. It burns with a blue flame, and a ſmell of greaſe, leaving a black viſcid matter, which is with more difficulty conſumed.

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method by which the good Engliſh pencils are made; whereas the method, indicated by Mr. Fourcroy, of employing the powder of this mineral, made into a paſte with ſulphur, or mixed with ſome mucillagenous ſubſtance, is never employed but by ſome poor Jews, who ſell theſe pencils very cheap for carpenters work, and other coarſe drawings.

One part of plumbago, with three of clay, and ſome cows hair, makes an excellent plaſter for covering retorts in chemical laboratories, as it keeps the ſame form, even after they happen to melt with the force of fire.

The famous crucibles of Ypſen, are made at Paſſaw, in Saxony, with plumbago mixed with clay: they are known in England by the name of *Heſſian crucibles*; but there is now a manufactory of the ſame kind at Chelſea, near London, where crucibles are made nearly as good as the foreign ones. The powder of *black-lead* ſerves alſo to cover the ſtraps of razors; and it is with it, that caſt-iron work, as ſtoves and the like, receive a ſhining ſurface; but an uſeful application of this ſtuff, not generally known, is to ſmooth the ſurfaces of wood-work, which ſlide one over the other, ſuch as *wooden-screws, packers-preſſes*, &c. as neither greaſy nor oily ſubſtances, or any kind of ſoapy ointments, produce ſo good an effect on them. *The Editor.*

It is ſoluble in ſpirit of wine, only when tartarized: and even then leaves an inſoluble reſiduum; but expreſſed oils diſſolve it when boiling.

It is alſo found in ſome rocky parts of Perſia, but ſeems mixed with Petrol, and is there called *Schebennaad*, *Tſienpen*, *Kodreti*.

Mr. Herman, a phyſician of Straſburg, mentions a ſpring in the neighbourhood of that city, which contains a ſubſtance of this ſort diffuſed through it, which ſeparates on ebullition, and may then be collected.

Thus far Mr. Kirwan, who, with great propriety, inſerted this ſubſtance in his *Elements of Mineralogy*, among Phlogiſtic Minerals; but Dr. Lippert was doubtful whether this ſubſtance could be claſſed amongſt them, though he has not given any good reaſon for excluding it.

But that there exiſts a fat mineral, like *tallow* or *butter*, has been lately proved by the extraction of a greaſy ſubſtance out of peat in Lancaſhire, as will be mentioned in Sect. 250. *The Editor*.

SECT.

SECT. 233. (145.)

Ambergris. *Ambra griſea.*

It is commonly reckoned to belong to the mineral kingdom, although it is ſaid to have doubtful marks of its origin [*a*].

a. It

[*a*] Ambergriſe, according to the aſſertion of Mr. Aublet, (in his *Hiſtoire de la Guyane*, printed in 1774), is nothing more than the juice of a tree inſpiſſated by evaporation into a concrete form. This tree grows in Guyana, and is called *Cuma*, but has not been inveſtigated by other botaniſts. When ſome branches are broken by high winds, a large quantity of the juice comes out: and, if it chances to have time to dry, various maſſes (ſome of which had been ſo large, as to weigh 1200 pounds and more), are carried into the rivers by heavy rains, and through them into the ſea: afterwards they are either thrown into the ſhore, or eaten by ſome fiſh, chiefly the ſpermaceti-whale, known by the name of *Phyſeter-Macrocephalus*, among Ichyologiſts. This kind of whale is very greedy of this gum-reſin, and ſwallows ſuch large quantities, when it meets with it, that they generally become ſick; ſo that thoſe employed in the fiſhery of theſe whales, always expect to find ſome amber, mixed with the excrements and remains of other food, in the bowels of thoſe whales, who are lean. Various authors, among whom is Father Santos, in his *Ethiopia Oriental*, who travelled to various places of the African coaſt, and Bomare, ſay, that ſome ſpecies of birds are fond of eating this ſubſtance, as well as the whales and other fiſhes. This accounts very well for the *claws*, *beaks*, *bones*, and *feathers* of *birds*; parts of *vegetables*; *ſhells* and *bones of fiſh*, and particularly for the *beaks* of the *cuttle* fiſh, or *ſepia octopedia*, that are ſometimes found in the maſs of this ſubſtance. Dr. Swediar, however, attended only to theſe laſt, though

a. It has an agreeable ſmell, chiefly when burnt:

b. Is conſumed in an open fire:

c. Softens in a ſlight degree of warmth, ſo as to ſtick to the teeth, like pitch.

d. It is of a black or grey colour; and of a dull or fine grained texture [*b*].

The

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though he had mentioned alſo the other ſubſtances in his paper, inſerted in the *Philoſophical Tranſactions* for 1783, wherein he attempts to eſtabliſh the very erroneous opinion, that the amber is nothing elſe but a preter-naturally hardened dung, or fæces of the *phyſeter whale*. It is not a little ſurpriſing, that both Dr. Withering and Mr. Kirwan have embraced this ill-grounded notion. Certainly they did not read that paper with any ſort of attention, or they would have perceived the futility of his reaſoning.

[*b*] The late Mr. Aublet abovementioned, with whom I was intimately acquainted, gave me ſome ſpecimens of this gum-reſin, which he collected, on the ſpot, from the *cuma tree*, at Guyana. The beſt of theſe I preſented to my late worthy friend Dr. Fothergill, who, for the eminent qualities of his mind, and the benevolence of his heart, will be ever regretted by all that knew him. From the remainder of theſe ſpecimens, I gave the beſt to my worthy friend Dr. Combe; F. R. S.: and the reſt I ſtill keep. It is of a whitiſh brown colour, with a yellowiſh ſhade; it melts and burns like wax on the fire, but it is rather of a more powdery conſiſtency than any amber I have ſeen, probably on account of the improper ſeaſon in which it was collected. The ſingularity of this gumo-reſin is, that it imbibes very ſtrongly the ſmell of the aromatic ſubſtances which ſurround it; and it is well known, that perfumers avail themſelves very conſiderably of this advantage. My late friend, Mr. Rouelle, one of the greateſt chemiſts of France, examined very carefully, this ſubſtance brought over by Mr. Aublet: and found that it produced the very ſame reſults as any other good kind of amber. Beſides Mr. Aublet's authority, which is deciſive, as being

grounded

The grey is reckoned the beſt, and is ſold very dear. This drug is brought to Europe from the Indies. It is employed in medicine: and alſo as a perfume [c].

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grounded upon direct proofs of fact, Rumphius, quoted by Bergman, long ſince mentioned a tree, called *Nanarium*, whoſe inſpiſſated juice reſembles amber. It cannot therefore at preſent be doubted that the origin of this phlogiſtic ſubſtance is the vegetable kingdom; although it may be often found and reputed, as a product of the foſſil kind.

This ſubſtance, being analyſed by Meſſrs. Geofroy and Newman, quoted by Mr. Fourcroy, yielded them the ſame principles, as the bitumens; *viz.* an acid ſpirit, a concrete acid ſalt, ſome oil, and a charry reſiduum; which evidently evinces, I think, that all theſe fat and oily foſſil ſubſtances, have their origin from the other two kingdoms of Nature. *The Editor.*

[c] Ambergriſe is not only brought from the Eaſt Indies, but from the coaſts of the Bahama Iſlands, Braſil, Madagaſcar, Africa, China, Japan, the Molucca Iſlands, the coaſts of Coromandel, Sumatra, &c. Dr. Lippert, in the Treatiſe he publiſhed at Vienna, in 1782, entitled *Phlogiſtologia Mineralis*, has copied chiefly from Wallerius what he aſſerts of this ſubſtance. He affirms that there are eight known ſpecies of amber, five of a ſingle colour; *viz.* the white and the black from the Iſland of Nicobar, in the Gulph of Bengal, the aſh coloured, the yellow, and the blackiſh; and two variegated; *viz.* the grey coloured with black ſpecks, and the grey with yellow ſpecks. This laſt he aſſerts to be the moſt eſteemed on account of its very fragrant ſmell, and to come from the South coaſt of Africa and Madagaſcar, as well as from Sumatra; and that the black dark coloured amber is often found in the bowels of the cetaceous fiſhes. The ſame author adds alſo from Wallerius, that by diſtilling the oil of yellow amber (ſuccinum) with three parts and a half of fuming nitrous acid, a reſiduum remains like roſin, which emits a perfect ſmell of muſk; from whence ſome conclude, that the ambergriſe belongs to the foſſil kind: the contrary, however, is evinced in the preceding Note. *The Editor.*

SECT. 234. (146.)

Amber. *Ambra flava. Succinum. Electrum:* Lat. *Carabé*, French. *Agtſtein, Bernſtein*, Germ.

This is a ſubſtance which is dug out of the earth, and found on the ſea-coaſts. According to the experiments of Mr. Bourdelin, it conſiſts of an inflammable ſubſtance, united with the acid of common ſalt, which ſeems to have given it its hardneſs [*a*].

It

[*a*] The yellow amber, or *carabé*, as the French call it, is a hard, brittle, taſteleſs ſubſtance.

Its ſpecific gravity is from 1065 to 1100.

Its fracture is even, ſmooth, and gloſſy, capable of a fine poliſh; and

Becomes electric by friction.

When rubbed or heated, it emits a peculiar agreeable ſmell, particularly when it melts, for which effect it requires a heat of 550 degrees of Fahrenheit's thermometer, but it then loſes its tranſparency.

Projected on burning coals, it burns with a whitiſh flame and a whitiſh yellow ſmoke; it gives very little ſoot, and leaves browniſh aſhes.

It is inſoluble in water or ſpirit of wine; though this latter, when rectified, extracts from it a reddiſh colour.

It is ſoluble in the vitriolic acid, which then acquires a reddiſh-purple colour; and may be precipitated by water. No other acid diſſolves it.

Nor is it ſoluble in fixed alkalis, nor in eſſential or expreſſed oils, without ſome decompoſition, and a long digeſtion.

But balſams diſſolve it readily.

73 gr.

It is ſuppoſed to be of vegetable origin, ſince it is ſaid to be found together with wood in the earth.

By diſtillation it yields water, oil, and a volatile acid ſalt, which the above-mentioned author has thought to be the acid of common ſalt, united with a ſmall portion of phlogiſton.

Inſects,

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75 gr. of this ſubſtance neutralize 100 gr. of nitrous acid; and of courſe, 100 gr. of yellow amber contain nearly 90 of phlogiſton.

By diſtillation it affords a ſmall quantity of water, an oil of the nature of petrol, and the peculiar acid called the *ſuccineous*, already mentioned in Sect. 166.

100 grains of amber afford about 72 of petroleum; 4.5 of ſalt, *viz.* of the ſuccineous acid; the remainder is a fixed matter, and water.

According to Scheele, this amber yields, by diſtillation, an aqueous acid, which poſſeſſes all the qualities of vinegar. If ſo, it is probably of a vegetable origin. *Kirwan.*

My late friend, Dr. Fothergill, was ſo perſuaded of the truth of this laſt mentioned opinion concerning the origin of this ſubſtance, that he often propoſed to the curious, the attempt of hardening various roſins by a long depoſition, or long ſtanding, ſurrounded by acids, in the ground, or in proper veſſels. A paper of the Doctor's may be ſeen in the Philoſophical Tranſactions for 1743, N° 472, on this ſubject.

This kind of amber, ſays Mr. Fourcroy, is found in ſmall detached pieces, for the moſt part under coloured ſands, diſperſed in beds of pyritaceous earth; and above it is found wood, charged with a blackiſh bituminous matter. Hence it is ſtrongly ſuppoſed, that it is a reſinous ſubſtance, which has been altered by the vitriolic acid of the pyrites; notwithſtanding that we know that acids, when concentrated always blacken, and charry reſinous ſubſtances. In fact, the chemical analyſis of this ſubſtance rather confirms that ſuppoſition.

The ſingular opinion of Dr. Girtanner, about the *yellow amber* being produced by a kind of ants, may be ſeen in *Journal de Phyſique*, for March 1786, page 227.

The

Inſects, fiſh, and vegetables, are often found included in it, which teſtify its having once been liquid.

It is more tranſparent than moſt of the other bitumens; and is doubtleſs the ſubſtance which firſt gave riſe to *electrical experiments* (on account of the power it poſſeſſes of attracting little

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The colour, texture, tranſparency, and opacity of this ſubſtance, have ſhewn ſome other varieties, beſides thoſe mentioned in the text, the principal ones are the following;

6. The yellow opaque *ſuccinum*
7. The coloured *green* or *blue*, by foreign matter } opaque
8. The veined ſuccinum
9. The white
10. The pale-yellow
11. The citron-yellow } tranſparent.
12. The deep-red

The golden-yellow tranſparent amber, mentioned by the Author, is what the Antients called *Chryſoelectrum:* and the *white opaque* was called *Leucoelectrum.*

But we muſt be cautious about the value of the ſpecimens, remarkable for their colour, ſize, tranſparency, and the well-preſerved inſects they contain internally; ſince there is a probability of deception, ſeveral perſons poſſeſſing the art of rendering it *tranſparent*, *coloured*, and of *ſoftning* it, ſo as to introduce foreign ſubſtances, &c. into it at pleaſure.

Mr. Fourcroy ſays, that two pieces of this ſubſtance may be united, by applying them to one another, after being wet with *oil of tartar*, and *heated*; and Wallerius mentions, that pieces of yellow amber may be ſoftened, formed into one, and even diſſolved by means of oil of *turnep-ſeed*, in a gentle heat; and that, according to ſome authors, it may be rendered pure and tranſparent, by boiling it in *rape-ſeed-oil*, *linſeed oil*, *ſalt water*, &c.

Mr. Macquer ſays, that for the purpoſe of making varniſh, this ſubſtance muſt undergo beforehand a previous decompoſi-

tion

tle bits of ſtraw, or of other light ſubſtances, when rubbed).

It's varieties are reckoned from its colour and tranſparency. It is found

A. Opake. *Succinum opacum.*

a. Brown.

b. White.

c. Blackiſh.

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tion by torrefaction, in order to be diſſolved by *linſeed-oil*, or *eſſential-oils*.

According to Jaubert (in his Dictionaire des Arts), two ounces of *aloes*, and as many of *carabé*, being well diſſolved with 12 ounces of linſeed-oil, in a glazed earthen pot, untill the whole be uniformely incorporated, makes an excellent varniſh like that of China and Japan. Great care, ſays he, muſt be taken to avoid its catching fire in the proceſs. But I believe the mixture of aloes to be a miſtake; as, upon enquiry, I find no where elſe any mention of *aloes* among the receits or formulas for making varniſhes. Unhappilly this kind of books is never publiſhed by good, practical, and honeſt artiſts, becauſe they in general make a ſecret of their crafts; and of courſe we cannot put any reliance either on ſcribling theoriſts, or on catch-penny publiſhers, who hardly know the names of the things they deſcribe.

Beſides, the making varniſhes with yellow-amber, this ſubſtance was much employed formerly in making various pieces of ornament and jewellery: the beſt pieces were cut, turned, carved, or plained, to make vaſes, heads of canes, colars, bracelets, ſnuff-boxes, beeds, and other ornaments, ſmall fine cheſts, &c. But after diamonds, precious and beautifull hard ſtones were brought to uſe, theſe trinkets are little conſidered in Europe: nevertheleſs, they are ſtill ſent to Perſia, China, and to various other Eaſtern nations, who eſteem them ſtill as great rarities.

Mr. Fourcroy quotes Wallerius, ſaying, that the tranſparent lumps of this ſubſtance may be employed for making *microſcopes*, *burning-gloſſes*, *priſms*, &c. But this author mentions no ſuch thing in his edition of 1778: nor could it be preferred

c. Blackiſh.

B. Tranſparent. *Succinum diaphanum.*

a. Colourleſs.

b. Yellow.

The greateſt quantity of European amber is found in Pruſſia; but it is, beſides, collected on the ſea-coaſt of the Province of Skone; and at Biorko; in the Lake Malaren, in the Province of Upland; as alſo in France and in Siberia. It is chiefly employed in medicine, and for making varniſhes.

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preferred to glaſs on any account, except for trying the different refrangibility, and modifications of light. He adds alſo, a report of the King of Pruſſia poſſeſſing a burning-lens a foot diameter, of this foſſil ſubſtance; and that in the cabinet of the Duke of Florence, a column of amber was ſeen, ſix feet high, and a very beautiful luſtre: theſe both I have no objection to believe; they being rather an object of oſtentation and luxury, than of any real uſefullneſs.

The Copal is a ſubſtance very ſimilar to yellow amber, although not ſo hard, and of courſe it takes a leſs beautiful poliſh. Some Mineralogiſts, among whom is Lehman, reckon it among foſſils; but Boch, quoted by Kirwan, has ſhewn it belongs to the vegetable kingdom.

Its chemical products are for the moſt part the ſame as thoſe of the yellow amber; but it does not produce any acid ſalt.

It is commonly called Gum-Copal, which is a very improper denomination, as it is a true roſin. Mr. de Bomare deſcribes the tree which produces this roſin. It grows in New Spain; and Linnæus ſpeaks of one called by him *Rhus copalinum*, &c. but it is alſo found on the ſea coaſt, as well as the yellow amber. Some confound the one of theſe two ſubſtances with the other; but it is evident that they are very different. It is generally employed in making varniſhes by diſſolution in oils, or in camphorated ſpirits of wine, &c. *The Editor.*

SECT.

SECT. 235. (147.)

Rock-oil. Naphtha [*a*].

This is an inflammable mineral ſubſtance, or a thin bitumen, of a light brown colour, which cannot be decompoſed; but is often rendered impure by heterogeneous admixtures. By length of time it hardens in the open air, and then reſembles a vegetable reſin; in this ſtate it is of a black colour, whether pure or mixed with other bodies. It is found,

A. Liquid.

1. Naphtha [*b*].

This is ſaid to be of a very fragrant ſmell [*c*], tranſparent, extremely inflammable, and attracts

[*a*] Phlogiſton occurs alſo in the foſſil kingdom, combined in an oily form, but many ſuppoſe this derived from the vegetable kingdom. *Berg. Sciagr.*

Three varieties of Naphta are known, the *white*, the *reddiſh*, and the *green*, or deep coloured. It is in fact a true petrol, of which the lighteſt, the moſt tranſparent, and moſt inflammable, is diſtinguiſhed by this name of *Naphtha*. Mongez.

[*b*] It is a fine thin coloured oil. It ſwims on all fluids, and is very volatile. Is not decompoſed by diſtillation; and yet, if long expoſed to the air, it changes colour, thickens, and degenerates into petrol. Its ſpecific gravity is =0,708. *Kirwan* and *Mongez*.

[*c*] Its ſmell is agreeable enough; but is very different from that of vegetable oils. It diſſolves reſins and balſams, but not *gum-reſins*, nor *elaſtic-gum*. It diſſolves in the eſſential oils of thyme and lavender; but is inſoluble in ſpirit of wine and æther. *Kirwan*.

gold [*d*]. It is collected on the surface of the water in some wells in Persia [*e*].

[*d*] It burns with a bluish yellow flame, and is as inflammable as æther; and, like it, attracts gold from *aqua regia*. *Kirwan*.

[*e*] It issues out of white, yellow, or black clays, in *Persia* and *Media*. *Kirwan*.

The finest naphta is brought from a peninsula in the Caspian Sea, called *Okefra* by Kempfer. It issues out through the earth, into cisterns and wells, purposely excavated for gathering it at *Baku* in Persia.

Different Naphtas are found also in Italy, in the Dutchy of Modena, and in Mount *Ciaro*, twelve leagues from Plaisance.

Most naturalists and chemists ascribe the formation of *Naphta*, *Petrol*, &c. to the decomposition of solid bitumens by the action of subterraneous fires; so that *Naphta* is the lightest oil which fire disengages first: what follows, acquiring colour and consistence, forms the different sorts of *petrol*; and these last, united with some earthy substances, or altered by acids, assume the appearance of *mineral pitch*, *piſſasphaltum*, &c. The phænomena, which the distillation of yellow-amber presents, seem to support this opinion, as it really furnishes a kind of *naphtha*: then a *petroleum*, more or less brown: and finally, a black substance, like the *jet*, which, urged by the fire, leaves a brittle and porous matter, &c. They observe further, that Nature presents frequently all kinds of petrol near the same spot, from the lightest naphta to the mineral pitch, as may be observed at Mount *Feslin*, in the Dutchy of Modena. But although this opinion be the most plausible, some think that these mineral oils, or bitumens, are formed from the vitriolic acid, and various oily and fat substances of the *vegetable* and *animal* kingdoms, buried under the earth by the ancient convulsions and revolutions of this globe, previous to all historical records of mankind. *The Editor from* Wallerius, Mongez, Kirwan, Fourcroy, *&c.*

SECT.

SECT. 236. (148.)

2. Petrol. *Petroleum*, Lat. *Bergöel*, *Steinoel*, Germ.

This ſmells like the oil of amber, though more agreeable; and likewiſe very readily takes fire. It is collected, in the ſame manner as the Naphta, from ſome wells in Italy, and in a deſerted mine at Oſmundſberget, in the province of Dalarne. At this laſt-mentioned place, it is found in ſmall hollows in the lime-ſtone, as reſin is in the wood of the pine-tree [*a*].

SECT.

[*a*] Doctor Prieſtley has ſhewn, in the third volume of his Obſervations and Experiments on Air, that eſſential oils, long expoſed to the atmoſphere, abſorb not only the pure part, but alſo the phlogiſticated part of it: an abſorption, which muſt in time produce conſiderable changes in them. By a proceſs of this ſort, naptha is converted into petrol, which is an oil of various degrees of denſity, according to the time during which it has been expoſed to the atmoſphere. Petrol is found trickling from rocks, or iſſuing from the earth, in the Dutchy of Modena, and in various parts of France, Swiſſerland, Germany, and Scotland, as well as in Aſia; alſo on the ſurface of the water of different fountains, or mixed with earth and ſand, from which it is ſeparated by infuſion in water. The thinneſt ſort poſſeſſes the properties of naphtha, though in a leſs degree. It is rendered finer by diſtillation with water, and leaves a reſinous reſiduum; and if diſtilled with a volatile alkali, the alkali acquires the properties of ſuccinated ammoniac, and contains the acid of amber. Some ſorts of it, according to Monet, are nearly of the denſity of nut-oil. It is inſoluble in ſpirit of wine. *Kirwan.*

SECT. 237. (149.)

Maltha. Barbadoes-tar.

Petroleum tenax. Kedria-terreſtris, Lat.
Erdepech, Bergtheer, Germ.

B. Thick and pitchy rock-oil.

This reſembles ſoft pitch [*a*]

It

The diſtinct character of the petrol, is its thickneſs, reſembling inſpiſſated oil: its ſmell approaches that of turpentine, or rather oil of amber: its flavour is of a penetrating ſharpneſs; and, when pure, it is lighter than ſpirit of wine. In proceſs of time it looſes its ſmell and former colour, becoming black and thick.

There are three varieties of Petrol, *viz.*

The yellow, very light and volatile. It is found near Modena in Italy.

The reddiſh, or yellow-red; ſome of which is collected near Gabian in Languedoc, and in Alſatia.

And the black, or brown, which is heavier and more common. This is found in England, France, Italy, Germany, Sweden, and in various other places. It generally either runs out from the chinks, or gaps of rocks; or is mixed with the earth, and guſhing out of it; or ſwimming on the water of ſome fountains, &c. *Mongez.*

Dr. Lippert ſays, that on mixing fuming *nitrous* acid with petrol, a kind of roſin is produced, whoſe taſte is very bitter, but the ſmell is like that of *muſk*; and that the *vitriolic acid* produces with it a ſtill more bitter ſubſtance, but without that aromatic ſmell. *Editor.*

[*a*] Petroleum, long expoſed to the air, forms this ſubſtance. It is of a viſcid conſiſtency; and of a brown, black, or reddiſh black colour. Sometimes inodorous, but generally

of

It is found in Moſſgrufvan, at Norberg, in the province of Weſtmanland, and at the Dead Sea in the Holy Land [*b*].

SECT. 238. (Additional.)

Elaſtic Petrol.

This is a very ſingular foſſil found of late in England.

By its colour and conſiſtency it exactly reſembles the *Indian-rubber*, or the *gum-reſin* from the North part of Braſil, called *Caoutchouc*, commonly uſed for rubbing the traces of *black-lead pencils* from paper, as was mentioned in the Note to *page* 454.

It is of a dark brown colour, almoſt black; and ſome is found of a yellowiſh brown-caſt, like the ſame gum-reſin.

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of a more or leſs diſagreeable ſmell, particularly when burned. It eaſily melts, and burns with much ſmoak and ſoot; and leaves either aſhes or a ſlag, proceeding from the heterogeneous matter it contains.

It is inſoluble in ſpirit of wine.

Contains a portion of the ſuccinous acid; ſince it gives, with mineral alkali, a bitter ſalt, more difficultly diſſoluble than common ſalt, and which, being treated with charcoal, will not afford ſulphur. *Kirwan.*

[*b*] It is found in Perſia, in the chinks of rocks, and in ſtrata of gypſum and lime-ſtone; or floating on water; alſo in *Siberia*, *Germany*, *Switzerland*, in coal-pits; and in *America*. Kirwan.

And alſo in Colebrookdale in England. *Brun.*

With reſpect to its elaſtic conſiſtence, it hardly can be diſtinguiſhed from it, except in the coheſion of its particles, which is weaker.

It has the ſame property of rubbing off from paper the traces of black-lead pencils.

It burns likewiſe with a ſmoky flame; and alſo melts into a thick oily fluid; but emits a diſagreeable ſmell, like the *foſſil pitch*, or *Barbadoes-tar* of the laſt Section.

It is found in the ſame earthy and ſtony beds as petrol; namely, among ſpar and lead-ores; and ſome lumps of this hard ſubſtance (*viz.* the *Aſphaltum* of the following Section) are found in the ſame ſpot along with it.

Some ſpecimens of this foſſil are of a cylindrical form, like bits of thin branches or ſtalks of vegetables, though much more flexible, being perfectly elaſtic.

Upon the whole, this foſſil ſeems to confirm the opinion already mentioned, Note to page 466, of thoſe Mineralogiſts, who believe that theſe oily combuſtibles derive their origin from the vegetable kingdom. It ſeems worth trying, whether pieces of Aſphaltum, buried in damp beds of ſparry rubbiſh, or other kind of earths, would take the ſame elaſtic conſiſtence.

But ſince many beds of *ſhells* and other *foſſil ſubſtances*, both of the *vegetable* and *animal kind*, as impreſſions of various *plants*, and the remains of various *quadrupedes*, &c. have been found in different parts of the globe, whoſe individual ſpecies undoubtedly exiſt no longer alive unleſs

unleſs in far diſtant climates, and in the moſt remote countries from the ſpot where their exuvia are digged out; why ſhould we not allow that this new foſſil may be the ſame original *elaſtic gum*, now growing naturally in *Brazil*, *China*, and other *hot climates*, only altered in its ſmell, and in the tenacity of its particles, by the long ſtanding during centuries, and even myriades of years, buried in the bowels of the earth?

This elaſtic petrol was found in 1785, near *Caſſelton*, in the County of *Derbyſhire*, in *England*, but in very inconſiderable quantities, of which I got ſome very ſmall pieces. *The Editor.*

SECT. 239. (150.)

C. Hardened Rock-oil. Foſſil Pitch. *Petroleum induratum. Pix montana.* Lat. *Iudenpech, Berghartz, Steinpech, Erhartete, Bergtheer.* Germ.

1. Pure, *Aſphaltum.*

This leaves no aſhes or earthy ſubſtance when it is burnt [*a*].

[*a*] This is a ſmooth, hard, brittle, inodorous, black or brown ſubſtance. When looked through, in ſmall pieces, appears of a deep red colour. It ſwims in water.

It breaks with a ſmooth ſhining ſurface. Melts eaſily: and, when pure, burns without leaving any aſhes; but if impure, leaves aſhes or a ſlag.

According to Mr. Monet, it contains ſulphur, or at leaſt the vitriolic acid.

It is ſlightly and partially acted on by alcohol and æther. *Kirwan* and *Margraaf.*

It is found at Finnberget, in the parish of Grythytta, in Westmanland [*b*].

From this or the preceding substance, it is probable, the asphaltum was prepared that the Egyptians used in embalming their dead bodies, and which is now called *Mummia.*

2. Impure, *Pix montana impura.*

This contains a great quantity of earthy matter, which is left in the retort after distillation, or upon the piece of charcoal, if burnt in an open fire; it coheres like a slag, and is of the colour of black-lead; but in a calcining heat this earth quickly volatilises, so that the nature of it is not yet known [*c*].

It is found in Mossgrufvan in Norberg, and in Grengierberget, both in the province of Westmanland: and also in other places [*d*].

[*b*] It is found also on the shores of the *Red Sea*, in the Dead Sea, in *Germany*, and *France*. Kirwan.

And it comes likewise from *Porto Principe*, in the island of Cuba. *Brun.*

Is found also in many parts of China: and is employed as a covering to ships by the Arabs and Indians. *Fourcroy.*

[*c*] The substance which rises, and then falls into the receiver during the distillation of this fossil pitch, is entirely the same as the common natural liquid rock oil of Sect. 148.

The Author.

[*d*] The *Pissasphaltum* is of a mean consistence, between the *Asphaltum* and the common Petroleum.

It is the very bitumen which is collected in Auvergne in France, in the well called *de la Pege*, near *Clermont-Ferrand.*

Mongez.

SECT.

SECT. 240. (Additional.)

Jet. *Gagas, Succinum nigrum.* Lat. *Jet,* or *Jayet.* French.

The *jet*, the *lapis obſidianus*, and the *foſſil wood*, penetrated by mineral inflammable matter, are often confounded together by Naturaliſts, on account of their black gloſſy colour, and ſome other common properties. But the *lapis obſidianus*, or *galinaceus*, is properly a glaſſy ſubſtance produced by volcanic fires, which muſt be placed in the Appendix among the volcanic productions, as well as the *foſſil-wood* deſcribed by our Author in his Sect. 285.

As to the jet, it is a very compact bitumen, harder than aſphaltum, always black, and ſuſceptible of a good poliſh. It becomes electrical when rubbed, and attracts light bodies like the yellow amber. It ſwims on water, and of courſe its ſpecific gravity muſt be leſs than 1000, whilſt that of the *lapis obſidianus*, according to Kirwan, is no leſs than 1744.

It ſeems to be nothing elſe than a *black amber*, or *ſuccinum*, but ſpecifically lighter, on account of the greater portion of bitumen that enters into its compoſition. When burned it emits a bituminous ſmell.

It is never found in ſtrata, or in continued maſſes, like the quarries of foſſil ſtones, but in ſeparate

ſeparate and unconnected heaps, or in ſingle pieces like the true yellow amber, deſcribed in Sect. 234. *See* Bomare's Mineralogy, *tom.* 2. p. 435. *Edition of* 1774.

Great quantities of this foſſil have been dug up in the *Pyrenean* mountains; alſo near *Batalha*, a ſmall town in Portugal, where it is called *Azebiche:* and in *Galiza*, a Northern Province of Spain. It is found alſo in Ireland, Sweden, Pruſſia, Germany, and Italy, &c. [*a*].

This foſſil is uſed in making ſmall boxes, buttons, bracelets, and mourning jewels or trinkets. Sometimes it is employed for making black varniſhes with proper oils; and is ſaid, that when powdered, it makes with lime an extraordinary cement, both for hardneſs, duration, and ſolidity, &c.

Editor, from *Kirwan*, *Bomare*, *Lippert*, *Mongez*, &c.

[*a*] Jet ſo much reſembles Cannel-coal in its colour, in its hardneſs, in its receiving poliſh, in its not ſoiling the fingers when rubbed upon it, &c. that many authors confound the two ſubſtances together. Jet, however, when warmed by friction, has the property of attracting bits of ſtraw and other light bodies; but I never obſerved this property in any of the cannel-coals. *Watſon's Eſſays*, vol. III. p. 11

This reſpectable Author might add alſo the other characteriſtic of jet being lighter than water, as Wallerius, Bomare, Mongez, and others aſſert. If ſo, he muſt have been miſinformed by thoſe, who ſay that the cubic foot of jet weighs 1238, or at leaſt 1180 ounces, and that of cannel-coal 1273 ounces, on the ſuppoſition that the cubic foot of water weighs only 1000 ounces. *The Editor.*

SECT. 241. (157.)

Mineral Phlogiſton united with earths. *Phlogiſton minerale terris imbutum.*

A. with calcareous earth. Phlogiſton terrâ calcarea imbutum.

1. With *pure calcareous earth.* This is the *fetid*, or *ſwine ſpar* of Sect. 29.

SECT. 242. (157.)

Liver-ſtone. *Lapis hepaticus.*

B. Mineral phlogiſton united with calcareous (argillaceous, ponderous, and ſiliceous) earth, and vitriolic acid [*a*].

[*a*] This is the *liver ſtein* of the Swedes, and the *leber ſtein* of the Germans, already deſcribed in Sect. 52. The Noble author ſaid, in that place, that no calcareous earth could be found in this ſtone, although, when burned, it produced a very good lime. This certainly was a contradiction, ariſing from the want of a good analyſis never having been made before of this ſubſtance: but Bergman, in his Sciagraphia, Sect. 90. affirms, that 100 parts of this ſtone, contain 33 of *ſiliceous* earth; 29 of cauſtic *ponderous* earth; almoſt 5 of *argillaceous* earth, and 3.7 of *lime*, beſides the *vitriolic* acid, and the water of cryſtallization. Mr. Kirwan, however, quotes another analyſis of the ſame Profeſſor Bergman, by which it appears, that 100 parts of the *hepatic ſtone* contain 33 of *baroſelenite*, 38 of *ſiliceous* earth, 22 of alum, 7 of gypſum, and 5 of mineral oil. *Editor.*

SECT.

SECT. 243. (158.)

Pitt, or ſtone-coal. *Lithanthrax.*

C. With an argillaceous earth, *Phlogiſton argillâ mixtum.*

1. With a ſmall quantity of argillaceous earth, and vitriolic acid. Coal. *Lithanthrax* [*a*].

It is of a black colour, and of a ſhining texture; it burns, and is moſtly conſumed in the fire; but leaves however a ſmall quantity of aſhes.

a. Solid coal.

b. Slatty coal [*b*].

Found in England, and at Boſerup in the province of Skone.

SECT.

[*a*] It is a black, ſolid, compact, brittle, inflammable ſubſtance; of a moderate hardneſs, lamellated texture, more or leſs ſhining, but rarely ſuſceptible of a good poliſh; and does not melt when heated.

According to Kirwan, it conſiſts of petrol, or aſphaltum, intimately mixed with a ſmall proportion of earth, moſtly argillaceous; ſeldom calcareous, and often with pyrites.

Spirit of wine extracts a red colour from it: cauſtic alkali attacks the bituminous part; and fat oils act on it, and form varniſh, at leaſt with ſome ſorts of it. Fixed alkali has never been found in it, nor any ſulphur, except when it contains pyrites.

None of the various kinds of pit-coal are electrics *perſe*. Kirwan.

[*b*] The varieties of pit-coal are very numerous, according to the proportion of each integrant part of their ſubſtance; but in

SECT. 244. (159.)

2. Culm-coal, called *Kolm* by the Swedes.

This coal has a greater quantity of argillaceous earth and vitriolic acid, and a moderate proportion of petrol.

It

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in regard to their economical uſes, only two varieties are attended to by the Legiſlature of England, eſtabliſhing a difference in the duty payable by *culm*, and *caking coals*; the laſt conſiſt of thoſe coals, that, in burning, ſhew a beginning to melt, ſo far that their ſmalleſt pieces run together, and unite by the adheſion of their ſurfaces: on account of this property it ſeems immaterial of what ſize the pieces are, ſince the ſmalleſt parts coaleſce by fuſion into conſolidated matter; and conſequently, the refuſe or droſs of theſe coals furniſh a fuel fit for the common economical purpoſes of life.

The other ſort of pit-coals, which are indicated by the name of *Culm*, or *Kolm*, in the following Section, do not fuſe, unite, nor cake by the application of heat, but retain their original form, and keep in detached pieces in the midſt of fire. The ſmall of this coal cannot therefore be applied to domeſtic uſe; becauſe, when in powder, this coal-duſt inſinuates itſelf between the crevices, prevents the circulation of air, and choaks up the fire, extinguiſhing it as compleatly as a parcel of incombuſtible matter. It is the fragments and duſt of this coal which conſtitutes *culm*, and which is only applicable to burn *lime-ſtone* for reducing it to *lime*, and to bake bricks, which are two very valuable articles of public concern.

It ſhould be an eaſy matter for any perſon to diſtinguiſh *culm* from ſmall *caking coal*, either by trying to make fire with it in a common grate, without interpoſing other fuel between it; for if it does, it is a *caking coal*; if not, it is *culm*; otherwiſe, by putting ſome of theſe ſmall fragments of coal on an ignited iron ſhovel; if they melt and run together, they belong

It has the ſame appearance with the preceding one, though of a more dull texture; it burns with a flame, and yet is not conſumed, but leaves behind a ſlag of the ſame bulk or volume as the coal was.

From England, and among the alum rock at Moltorp and Billingen in the province of Weſtergottland [*a*].

SECT.

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belong to the *caking kind:* if not, they are *culm.* But it ſeems that coal-merchants are now in the cuſtom of calling *culm* the powdry parts of pit-coal, of whatever ſort or kind they may happen to be.

There never was any difficulty on the ſubject; and there would be no trouble in collecting the tax, were it not for the inſufferable ignorance and love of deſpotic oppreſſion, which generally pervades the underling officers of the revenue.

Editor, chiefly from Ruſſel's Notes.

[*a*] Mr. Kirwan has given a deſcription of this kind of coal, extracted from The Memoirs of the Stockholm Academy. Its fracture has a rougher ſurface, than the *cannel-coal* of the following Section 246

Its ſpecific gravity is from 1360 to 1370.

The beſt coal of this ſort affords, by diſtillation, at firſt *fixed air*, then an *acid liquor*, afterwards *inflammable air*, and a *light* oil of the nature of petrol, then a *volatil alkali*; and, laſtly, *pitch-oil.* The reſiduum is nearly three quarters of the whole; and being ſlowly burnt, affords 13 *per cent.* of aſhes, which conſiſt moſtly of argillaceous earth: and about three hundred parts of them are magnetic.

However, according to the analyſis of Mr. Kirwan, 100 parts of this coal contain about 17 of earth, of which 4 are martial; and from hence it appears, that this coal does not conſiſt of a ſhiſtus penetrated with petrol, as ſome have thought, for then a large portion of ſiliceous, magneſian, and calcareous earths, ſhould be found in it.

SECT. 245. (160.)

3. Slate-coal [a].

This coal contains abundance of argillaceous earth. It burns with a flame by itself, otherwise it looks like other slates.

It is found at Gulleraſen, in the pariſh of Rettwik, in the province of Dalarne, and alſo with the coals at Boſerup in Skone.

SECT.

It will be neceſſary to notice here, that coal-merchants in general hardly make any difference in the ſpecific quality of pit-coals, provided they find buyers to diſpoſe of them, and that the duties or taxes be the leaſt poſſible to pay; ſo that what is called by them *Culm*-coal, means only the powdry rubbiſh, or droſs of any ſort of coals for making lime, or baking bricks, &c. *See Note [b] to the preceding Sect.* 243. The Editor.

[a] This laſt mentioned kind has induced me to believe, that the earth of the pit-coals is an argillaceous one, but is not ſo eaſy to be diſcovered after its being burnt. The pit-coals contain more or leſs of the vitriolic acid, for which reaſon the ſmoak, ariſing from them, attacks ſilver in the ſame manner as ſulphur does; though the coals be ever ſo free from marcaſite, which however is often found imbedded or mixed with them. *The Author.*

This is undoubtedly the *bituminous ſchiſtus*, already deſcribed in *Sect.* 148 among the *argillaceous earths*. I have ſeen, ſince that Section was printed, a conſiderable quantity of this flaty ſubſtance, which was ſent from *New-Hall*, near *Thirſk* in *Yorkſhire*, to Mr. Walker, Lecturer of Natural Philoſophy in London.

This

SECT. 246. (Additional.)

4. *Cannel-coal.*

Mr. Kirwan has put together this variety of coal, with that other called *Killkenny*-coal, though they have ſome different properties.

The *cannel-coal* is of a dull black colour.

Breaks eaſily in any direction; and, in its fracture, preſents a ſmooth conchoidal ſurface, if broken tranſverſely.

Contains a conſiderable quantity of petrol, in a leſs denſer ſtate than other coals.

Burns with a bright lively flame, but is very apt to fly in pieces in the fire. It is ſaid, however, to be entirely deprived of this property by being previouſly immerſed in water for ſome hours.

Its ſpecific gravity is about 1270.

And being of an uniform hard texture, may be eaſily turned in the laith, and receive a good poliſh.

This *ſchiſtus* is of a dark bluiſh ruſty colour: when thrown in the fire, burns with a lively flame, and as readily almoſt as the oily wood of dry *olive-tree*, or *lignum vitæ*; and emits the very diſagreeable ſmell of petrol. Mr. Walker extracted from it, by diſtillation, as much *liquid petrol*, as nearly its own bulk. I am well informed, that near *Purbeck*, in Dorſetſhire, ſuch large quarries of this ſlate are found, as to afford competent fuel to the poorer part of the inhabitants of that place.

The Editor.

It is from this kind of coal that ſmall vaſes, as ink-ſtands, various trinkets, and other curioſities, are made in England, which appear as if made of the fineſt Jet.

Editor, chiefly from *Kirwan*.

SECT. 247. (Additional.)

Kilkenny-Coal.

This coal contains the largeſt proportion of *Petrol* or *Aſphaltum*; burns with leſs flame and ſmoke, and more ſlowly, though intenſely, than the *cannel-coal*.

The quantity of earth in this coal, does not exceed one *twentieth* of its weight.

Its ſpecific gravity is about 1400.

It is frequently mixed with pyrites.

Is found in the County of Kilkenny, belonging to the province of Leinſter, in Ireland. The quality of this coal burning almoſt without ſmoke, is mentioned in a proverb, by which the good qualities of this County are expreſſed. *The Editor, chiefly from Kirwan.*

SECT. 248. (Additional.)

Sulphureous coal.

This conſiſts of the former kinds of coal, mixed with a notable proportion of pyrites:

hence it is apt to moulder and break when expoſed to the air.

It contains yellow ſpots that look like metal: And burns with a ſulphureous ſmell, leaving either red aſhes, or a ſlag, or both.

Water acts upon it, after it has mouldered.

Its ſpecific gravity is = 1500, or more.

Beſides the above varieties, ſhiſtus, micaceous ſhiſtus, and gneiſs, are frequently found in the neighbourhood of coal-mines, ſo penetrated with petrol, or bitumen, as to conſtitute an inferior ſpecies of coal; but the bitumen being burnt, they preſerve their form, and in ſome meaſure their hardneſs.

Alſo ſome grey ſlates, that are ſo ſoft as to be ſcraped with the nail, and are greaſy to the touch, burn like coal.

All the differences of coal ariſe from a mixture of the varieties already mentioned; and

It is obſervable, that wherever coals exiſt, ſlates are generally found near them. Salt, or mineral ſprings, are alſo often found in their neighbourhood. *Kirwan.*

SECT. 249. (Additional.)

Bovey Coal. Taub Kohle. Xylanthrax.

This is of a brown, or browniſh black colour, and of a yellow laminar texture.

The

The laminae are frequently flexible when firſt dug, though generally they harden when expoſed to the air.

It conſiſts of wood penetrated with petrol or bitumen, and frequently contains *pyrites*, *alum*, and *vitriol*.

Its aſhes afford a ſmall quantity of *fixed alkali*, according to the German chemiſts; but, according to Mr. Mills, they contain none.

By diſtillation it yields an ill ſmelling liquor, mixed with a *volatile alkali* and *oil*, part of which is ſoluble in ſpirit of wine, and part inſoluble, being of a mineral nature.

It is found in England, France, Italy, Swiſſerland, Germany, Ireland, &c. *Kirwan*.

SECT. 250. (Additional.)

Peat. *Geanthrax*.

There are two ſorts of inflammable ſubſtances known by this name; *viz.*

The firſt of a brown, yellowiſh brown, or black colour, found in mooriſh grounds; in *Scotland*, *Holland*, and *Germany*. When freſh, it is of a viſcid conſiſtence, but hardens by expoſure to the air.

It conſiſts of clay mixed with calcareous earth and pyrites: and ſometimes contains common ſalt.

While ſoft it is formed into oblong pieces for fuel, after the pyritaceous and ſtony matters are ſeparated.

When diſtilled it affords *water*, *acid*, *oil*, and *volatile alkali*.

Its aſhes contain a ſmall proportion of fixed alkali. They are either white or red, according as it contains more or leſs ochre or pyrites.

The ſecond is found near Newbury in Berkſhire. It contains but little earth; but conſiſts chiefly of wood branches, twigs, roots of trees, with leaves, graſs, ſtraw, and weeds.

Kirwan.

SECT. 251. (Additional.)

Stone-Turf.

The Noble Author has ranged the turf among the foſſils of his Appendix; but as that called in England by the name of *ſtone-turf*, contains a conſiderable proportion of peat, it may be mentioned with propriety in this claſs.

Soon after it is dug out from the ground, where it keeps a ſoft conſiſtence, it at firſt hardens; but afterwards it crumbles by long expoſure to the air.

As to the other common turf, it only conſiſts of mould interwoven with the roots of vegetables; but when theſe roots are of the bulbous kind, or in a large proportion, they form the worſt kind of turf.

Although it may appear incredible, it is nevertheleſs a real fact, that in England pit-turf is advantageouſly employed in *Lancaſhire*, to

ſmelt the iron-ore of that county. Mr. Wilkinſon, brother-in-law to the celebrated Dr. Prieſtley, and himſelf not leſs famous for his extenſive undertakings in the iron-works, perhaps the greateſt in all Europe, makes uſe of pit-turf in his large ſmelting furnaces of that province. I have ſeen, in the poſſeſſion of Mr. S. More, Secretary to the Society of Arts, a kind of *black tallow*, extracted by the ſame Mr. Wilkinſon, from *pit-turf*. It was very ſoft, and nearly of the ſame conſiſtence as butter. It burned very rapidly with a ſmoaky flame in the fire; but the ſmell was very diſagreeable like that of pit-turf. This confirms the opinion that the tallow deſcribed in Section 232, is probably of a foſſil extraction, as well as the other oils mentioned in the preceding Sections; although the origin of them all may be from the *vegetable* and *animal* kingdoms. *The Editor.*

SECT. 252. (Additional.)

Obſervations on Foſſil-Coals.

Theſe foſſil ſubſtances, which furniſh fuel for the various purpoſes of human life, are diſtinguiſhed by the name of *Coals*, on account of their being a ſuccedaneum for wood and other vegetable productions, which, when dry, or of an oleaginous kind, ſerve for the ſame uſes. If theſe vegetable ſubſtances are deprived of the

acceſs of air, by covering them after ignition, the half conſumed remainder, which is of a black colour, is called by the name of *Coal*, or *Char-coal*; and from hence the foſſil, which affords fuel, has alſo been called by the ſame name, though of a very different nature.

Pit-coal and *earth-coal* are ſynonymous, and mean *coals* dug out of a *pit*, or from the *earth*. But the *lithantrax* denotes *ſtone-coal*, and more properly indicates the *Cannel-coal* of Sect. 246; which has the greateſt ſimilarity to a *ſtony ſubſtance*, by the dull appearance of its fracture, and by the uniform texture of its parts.

All theſe coals are in general a bituminous black, or brown, and dark ſubſtance [*a*]: for the

[*a*] It is known that pit coal, or ſea coal, by diſtillation, gives out a phlegm, or watery ſubſtance; then an æthereal or volatile oil; afterwards a volatile alkali; and laſtly, a thick and greaſy oil. But it is remarkable that by rectifying this laſt oil, a tranſparent, thin, and light oil, of a ſtraw colour, is produced, which, being expoſed to the air, becomes black, like *animal oils*. *Fabroni*.

From this, and other obſervations, the moſt general opinion is, that all coals, bitumens, and oily ſubſtances, found in the mineral kingdom, owe their origin to the animal and vegetable remains buried in the bowels of the earth; ſince it is well known, that only organiſed bodies have the power of producing oily and fat ſubſtances. The amazing irregularities, gaps, and breaks of the ſtrata of coals, and of other foſſil ſubſtances, evince that this globe has undergone the moſt violent convulſions, by which its parts have been broken, detached, and overturned in different ways, burying large tracts of their upper ſurfaces, with all the animal and vegetable productions then exiſting, at the time of thoſe horrible cataſtrophes, whoſe epoch as far precede all human records. And it is eaſily

to

the moſt part they have a lamellated texture, which breaks eaſily, and almoſt always with a ſhining ſurface.

The varieties of pit-coals, already mentioned in the foregoing Sections, are the moſt remarkable, by which they may be diſtinguiſhed from one another [*b*]. But they are far from being homogeneous in each kind; as the accidental

to be conceived, that the various heaps and congeries of theſe vegetable and animal ſubſtances, remaining for ages and ages in different parts of the bowels of the earth, have obtained various conſiſtences, and ſtill produce thoſe oily and bituminous juices, which find way to guſh out, leaving behind their thickeſt parts on the ſame places where they are found, and in many others where the induſtry of mankind never will be able to penetrate. It will be ſeen by the laſt Sect. 259. of this Claſs, that our author inclines very much to this opinion. *See the* feeble arguments *of* Mr. le Camus *to prove the contrary, at page* 178. *of* Journ. de Phyſ. *for* March, 1779. *The Editor.*

[*b*] Mr. Bertrand, in his Oryctologic Dictionary, reduces all kinds of coals to ſix general claſſes, *viz.* 1. *Lithantrax Ligneus.* 2. *Petriſſus*: 3 *Terreſtris*: 4. *Piceus*: 5. *Fiſſilis*: 6. *Mineraliſatus.* He ſays, that the *Scotch coals* are heavier, and burn not ſo well as thoſe of Newcaſtle; that thoſe of Liege burn quicker, and thoſe from *Braſſac*, in Auvergne, and from *la Foſſe*, burn with a more agreeable flame, &c. But Mr. Morand, in his *Nomenclature raiſonnée*, diſtributes all ſorts of *Pit coals* into 4 claſſes: in the firſt he places 9 varieties, beginning with the *gagas*, *or ſuccinum nigrum*, to the *variegated lithantrax*: in the ſecond, he reckons 7 varieties, beginning with the *Lithantrax e'eganti ſtructura*, to that *facie granulata*: and he forms the fourth claſs with the earthy and poorer kind of foſſil coals. He ſeems, however, to have been puzzled with the flaty coals, as he ranges them in a ſeparate claſs, perhaps, to ſhelter himſelf from the critical objections of thoſe numerous ſuperficial naturaliſts, who only look for the apparent configuration, without almoſt any regard to the component parts of foſſils. *The Editor.*

qualities, and the various proportions of their component parts, produce a far greater number of properties, which renders them more or leſs fit for different purpoſes; though theſe are generally overlooked, and confounded with the common one of affording fuel for making fire, to warm our rooms, or for culinary operations.

In fact, various kinds of different coals are often found intermixed with one another in the ground. Some of the finer ſort run many times in form of veins between the layers of the coarſer kind; as I obſerved in the fine coals, the workmen employed at Birmingham, in a curious manufactory for moulding rods, or canes of tranſparent and coloured glaſs, into the required ſhapes for common buttons, with an aſtoniſhing expedition. The fire burned with ſo clear a flame as I never ſaw produced by common ſea-coal; and I found, upon inquiry, that this particular kind of coal, was picked out from the common coals of that country, it running in particular veins, which the manufacturers know well to be fit for their purpoſe, though I could not find any diſtinctive denomination to indicate this ſpecific difference. There is no doubt but a great field both for the theoretic inveſtigation of the nature and original formation of this foſſil, as well as for the practical knowledge of the uſes to which it may be advantageouſly employed, remains ſtill unexplored, or at leaſt is yet concealed among few intereſted practitioners, without affording any extenſive advantage to the public.

That

That kind of coal, diſtinguiſhed in London by the name of *Scotch-coals*, produce, when burned, white aſhes and a leſs dirty duſt than the common *Newcaſtle-coals*; though, among theſe laſt, ſome pieces of the Scotch kind are frequently found. On the contrary, thoſe I have ſeen in the fire-places at Wiltſhire, made ſuch a quantity of brown aſhes and dirty duſt, as to ſpoil the furniture in a ſhort time, unleſs proper care was taken to clean the rooms very frequently.

This foſſil bitumen, as Fourcroy remarks, being heated in contact with a body in combuſtion, and a free acceſs of air, kindles the more ſlowly, and with more difficulty, as it is more weighty and compact. When once kindled, it emits a briſk and very durable heat, and burns for a long time before it is conſumed. If extinguiſhed at a proper time, the remaining cinders may ſerve ſeveral times for a new firing, with a ſmall addition of freſh coals. The matter that is burned, and produces the flame, appears very denſe, as if united to another ſubſtance, which retards its deſtruction. Upon burning, it emits a particular ſtrong ſmell, which is not at all ſulphureous, when the earth-coal is pure, and contains no pyrites [c].

When

[c] Hence we ſee how falſe and deceiving are the propoſitions of ſome ignorant pretenders, who boaſt of proceſſes, to deprive pit-coals of ſulphur, as a great improvement to deſtroy the noxious qualities they ſuppoſe ariſing from this kind of fuel. But a general and conſtant experience of the numerous inhabitants of England, and of various other countries on the Continent, as at Liege, part of Holland, and the Auſtrian

When the combuſtible, oily, and moſt volatile parts, contained in the earth-coal, are diſſipated and ſet on fire by the firſt application of heat; if the combuſtion is ſtopped, the bitumen retains only the moſt fixed and leaſt inflammable part of its oil, and is reduced to a true charry ſtate, in combination with the earthy and fixed baſe. Pit coals in this charry ſtate are called *Coaks*, which are capable of exciting the moſt intenſe heat; and are employed all over England in the ſmelting of *iron*, *copper*, and other metallic ores to the greateſt advantage [*d*].

SECT.

Auſtrian Netherlands, where pit coals are the common fuel, evinces the fallacy of their impoſition; and to this I may add, the experience of above twenty-two years, during which I have lived in England, without ever finding in myſelf, nor in any of my numerous acquaintance, the leaſt alteration in health on this account. *The Editor.*

[*d*] It is well known that the Engliſh method of burning *pit coal* into *coak*, has been a moſt profitable and happy acquiſition, for the ſmelting our ores, and for many other metallurgical and chemical proceſſes in this iſland. But the ingenious and advantageous undertaking of Lord Dundonal, by which he turns to a very conſiderable profit the mines of coals in his and other eſtates, building ovens of a proper conſtruction to burn *pit coal* into *coak*, and, at the ſame time, to collect in ſeparate receptacles the *volatile alkali*, *oil*, *tar*, and *pitch*, which were generally loſt by the uſual method, deſerves to be noticed in this place, as it affords a very remarkable inſtance of the great loſſes to mankind, for want of carefully attending to every reſult from great proceſſes of art, when made in a large ſcale. Theſe ovens are ſo contrived as to admit an under ſupply of air; and the coals, after

SECT. 253. (151.)

Brimſtone. Sulphur.

The Mineral Phlogiſton, or Bitumen, united with the vitriolic acid, conſtitutes *ſulphur*, or Brimſtone [*a*].

This

after being kindled, decompoſe themſelves by a ſlow, but incomplete combuſtion, which does not deſtroy the ingredients. The reſiduum, left in the oven, proves to be the moſt excellent *cinders* or *coaks*; whilſt the volatile parts, which otherwiſe would be diſſipated in the air, are ſeparated and condenſed in reſervoirs, or receptacles of a capacious ſize, placed at proper diſtances beyond the reach of fire.

Monſ. Faujas de St. Fond, who viſited theſe works in a trip he made to Scotland, undertook to erect a ſimilar oven of the kind, on his going back to France: and it is rather ſingular, that he endeavours to eſtabliſh a claim of having diſcovered the ſame proceſſes before he ſaw them in Scotland; as if it did not reflect a greater honour on his induſtry, to carry back to his country ſome uſeful knowledge in conſequence of his travels, than to return as ignorant as our Engliſh travellers uſually do, whoſe acquiſitions ſeldom amount to more than the new faſhions, effeminate manners, and other ſilly trifles, which our degenerate Britons are now wont to call refined accompliſhments. *The Editor.*

[*a*] This has been the general doctrine of chemiſts ſince the time of the famous Stahl, who called, by the name of *Phlogiſton*, that very inflammable principle, that had been deſcribed by Beecher, under the name of *inflammable earth*. Stahl was the firſt who diſcovered the ſynthetic compoſition of ſulphur, by combining a combuſtible ſubſtance with *vitriolic acid*; and this has afforded the greateſt probability, amounting

This is very common in the earth, and diſcovers itſelf in many and various forms. It is found,

A. Native

---

amounting indeed almoſt to a demonſtration, of the truth of his theory. Macquer deſcribes this proceſs, which conſiſts in mixing equal parts of *fixed alkali* and *vitriolated tartar*, with about the fourth part of both of powdered charcoal, in a crucible: the mixture being well ſtirred with a wooden rod, and the covered crucible placed on the fire for a ſhort time, the matter is poured out, on a greaſed marble: emits a ſtrong diſagreeble ſmell, like that of rotten eggs: when cold, coagulates, and appears of a dark-red, or liver colour: and is a true *liver of ſulphur*. This being diſſolved in water, affords a yellowiſh precipitate on the addition of any acid, which being collected on the filtre, is found to be a true brimſtone.

According to this doctrine of Stahl, the *phlogiſton* of the charcoal unites with the vitriolic acid of the tartar, or of any other vitriolic compound, and forms ſulphur; but, according to the new pneumatic theory, at the head of which is one of the moſt ingenious chemiſts of our times, Mr. Lavoiſier, the rationale of theſe phenomena is quite the reverſe of what has been aſſerted by the followers of Stahl. Thoſe bodies which were called *phlogiſticated*, are nothing more, according to the new theory, than ſubſtances which have a great tendency to unite with *pure air*; a tendency, which in general conſtitutes *combuſtibility*. So that whenever Stahl affirms *phlogiſton* to be diſengaged, as in *combuſtion* and *calcination*; there is in fact nothing elſe, ſay the new theoriſts, but a real combination of this *pure air*, with ſome of the component parts of the burned ſubſtance, the proceſs being facilitated by the action of *heat*. On the other hand, in all the ſuppoſed combinations of phlogiſton, a diſengagement of air may be often obſerved to ſubſiſt, as is evident in the reduction of metallic calces, and in the decompoſition of bodies by the action of acids. In a word, in this pneumatic ſyſtem, all theſe compounds of Stahl, as *ſulphur* from vitriolic acid, and *metals*, from their *calces*, and *phlogiſton*, are only ſimple ſubſtances, which poſſeſs a great tendency to unite with *dephlogiſticated*

A. Native Sulphur, *Sulphur nativum.*

In this the two conſtituent parts are mixed in due proportion in regard to each other, according to the rules of that attraction which is between them; it is eaſily known,

1. By its inflammability, and by its flame [*b*].

2. By

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giſticated air. Thus metals unite with the ſame air on being calcined: and their calces, on being reduced by fire into their metallic ſtate, give out the air they had imbibed before. I muſt confeſs that the ſimplicity of the *Pneumatic Theory* is a great inducement to receive it; but until any *ſulphur* can be ſhown, preexiſting in the alkaline baſe of the *vitriolated tartar* (for the *vitriolic acid* runs off, according to this theory, in the form of *pure air*, to combine with the *charcoal*) no man, in an unprejudiced ſtate of mind, will venture to embrace ſuch a theory. Neither is it at all comprehenſible, how the ſame agent *fire* will produce two oppoſite effects in ſimilar circumſtances; viz. cauſing pure-air to *unite* with metallic bodies in *calcination:* and to be *ſeparated* from them, when they are revived by the ſame. *The Editor.*

[*b*] Sulphur evaporates gently at the 170 degree of Fahrenheit's thermometer.

Melts at 185 degrees; and

Flames at 302 degrees of the ſame thermometer.

Burns with a blue flame, and a diſagreeable ſuffocating ſmell.

Sublimes in cloſe veſſels, without decompoſition, except of a ſmall quantity, proportioned to the quantity of air contained in the veſſels.

When melted becomes red, but recovers its colour on cooling.

Its conſtituent parts, viz, the *vitriolic acid* and *phlogiſton*, are nearly in the proportion of 3 to 2; for 100 parts of ſulphur contain about 60 of this *acid*, and 50 of *Phlogiſton.*

It

2. By its ſmell, when burnt; and,
3. By its producing a liver of ſulphur, when mixed with a fixed alkali, like that made from artificial ſulphur [*c*].

It

It is a taſteleſs, hard, brittle, idioelectric ſubſtance, of a yellow greeniſh colour.

Its ſpecific gravity is from 1906 to 2350.

It is inſoluble in water, though, by long trituration, the water ſeems to take up ſome part of it; but it ſeems that it is rather diffuſed thro', than diſſolved in it.

Neither can ſpirit of wine unite to it, except when both are in a vaporous ſtate; and then 72 parts of ſpirit of wine take up *one* of ſulphur.

Is ſoluble in hot oils, and alſo in alkali, both in the dry and liquid way.

Is decompoſed by boiling in concentrated nitrous acid; partly decompoſed, and partly diſſolved by the vitriolic and dephlogiſticated nitrous acid. *Kirwan.*

[*c*] The two pure (cauſtic) fixed alkalis, *vegetable* and *mineral*, have a very remarkable action on this ſubſtance; as, they form true *livers of ſulphur*, which are moſt difficultly decompoſed, and the moſt permanent of all. They may be prepared by the *dry*, or by the *moiſt* way. In the firſt proceſs, equal parts of *lapis cauſticus* and *flowers of ſulphur* are fuſed in a crucible; then run on a marble plate; and, as ſoon as cooled, are broken into pieces, and kept in a phial with ground ſtople. But in the *humid way*, the liquor, or lie, of ſoap-boilers, is heated with a half of its weight of ſulphur; till it acquires a deep dark red colour; and is kept, after being filtrated, &c. The difference between theſe and the common livers, made of mild alkali, is very ſenſible; theſe laſt are of a paler colour, ſometimes they are greeniſh, and always leſs odorous. It ſeems that the aerial aid, which they retain, weakens their ſtrength.

The earthy, and ſaline earthy ſubſtances, have no action on the *liver of ſulphur*; but the acids precipitate the ſulphur in a fine white powder, called the *Magiſter ſulphuris*: and the

gas

It is found
a. Pellucid, of a deep yellow colour.
b. Opake, white, and greyiſh [*d*].

Theſe

---

gas it diſengages, is the above mentioned *Hepatic air* of Sect. 230.

Sulphur, nitre, and charcoal, when well mixed together in a proper proportion, form the well-known detonating ſubſtance, called *gun-powder*. One hundred pounds of that made at *Eſſone*, near *Corbeil* in France, contains 75 of nitre, 9 and *a half* of *ſulphur*, and 15 of charcoal; but in general one pound of gun-powder contains 12 of nitre, 2 of ſulphur, and 3 of charcoal. The opinion of producing, as is pretended, gun-powder without *ſulphur*, is quite groundleſs. The moiſture neceſſary for the powder's aſſuming the grained form, cryſtalliſes the nitre, as may be ſeen with a magnifier by cutting the grains through. It is owing to the *dephlogiſticated air*, diſengaged from the nitre, that the combuſtion of gunpowder is attended with ſo great a detonation and violence.

The *fulminating powder* is compoſed of 3 *ounces* of nitre, *two* of dry aerated ſalt of tartar, and *one* of *ſulphur*, well triturated in a warm marble mortar, with a wooden peſtle. About a drachm (60 or 72 gr.) of it in an iron ladle, over a gentle fire, detonates with ſuch a report as that of a cannon. Alſo a mixture of *liver of ſulphur*, with the double of *nitre*, detonates with equally as great a report. *Editor from Fourcroy.*

[*d*] *c*. Criſtallized, in octoedral priſms, with blunted points.

d. Tranſparent. Mr. Davila had been informed that this was brought from Normandy in France. *Brun.*

1. Native ſulphur is found in different forms, viz. either in ſolid pieces of indeterminate figure, running in veins through rocks; or in ſmall lumps, in gypſum and lime ſtones; in conſiderable quantities at *Solfatara*, and in the neighbourhood of volcanos; or cryſtalized in pale, tranſparent, or ſemitranſparent, octogonal, or rhomboidal cryſtals, in the cavities of quartz; and particularly in the

matrices

These are found in Siberia, at Bevieux in Switzerland, and at Solfatara near Naples.

It is often found on lime-ſtone, which the vitriolic acid has left untouched, having a ſtronger attraction to the phlogiſton, and therefore wholly uniting with it.

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matrices of ores: or in the form of ſmall needles over hot ſprings, or near volcanos. *Kirwan.*

Sometimes it is formed in old privies; of this I ſaw ſome lumps that were found in a very old privy at Paris, *Editor.*

2. United with clay in the aluminous ore of *La Tolfa*, and alſo at *Tarnowitz*, in Sileſia. This laſt reſembles a light grey earth; when dry, burſts, or cracks, in the water, like marl; and poſſeſſes a ſtrong peculiar ſmell like camphor. If diſtilled, the ſulphur ſublimes.

100 parts of this earth afford 8 of ſulphur, beſides gypſum, and a quantity of iron.

3. Mixed with *clay*, iron, and *ſelenite*. This compound is of a grey, brown, or black colour, found near *Rome*, *Auvergne*, *Spain*, and *Iceland*.

4. With lime-ſtone in the form of a *calcareous hepar*. This is found at *Tivoli* near Rome, and elſewhere in Italy. It is ſometimes diſſolved in mineral waters; *three pounds* of which contain as much as 25 *grains* of ſulphur. It often forms incruſtations on the brinks of theſe ſprings.

5. *In the form of an alkaline hepar*. This is ſaid to be found in ſome waters in Ruſſia: of this will be ſpoken in Sect. 255.

6. United to Iron and clay of pyrites, &c. of which hereafter, Sect. 254.

7. United to metallic ſubſtances, as in Sect. 257 and 258. *Editor chiefly from* Kirwan.

SECT.

SECT. 254. (152.)

B. Sulphur that has diſſolved, or is ſaturated with, metals. *Sulphur metallis ſaturatum* [*a*].

1. With iron, *Sulphur marte ſaturatum.*

Pyrites, or Copperas-ſtone, *Pyrites.*

This is the ſubſtance from which moſt ſulphur is prepared, and is therefore ranked here with all its varieties. It is hard, and of a metallic ſhining colour.

a. Pale yellow Pyrites, *Pyrites ſubflavus.*

Marcaſite.

This is very common, and contains a proportionable quantity of ſulphur with reſpect to the iron; when once thoroughly inflamed, it burns by itſelf.

1. Of a compact texture, *Texturâ æquali*, called *Piedra del Ynca*, in Spain.
2. Steel-grained, *Texturâ chalybeâ.*
3. Coarſe-grained, *Texturâ granulatâ.*
4. Cryſtalliſed, *Chryſtalliſatus.*

It ſhoots moſtly into cubical and octoedral figures, though it alſo criſtalliſes into innumerable other forms [*b*].

SECT.

[*a*] Sulphur is the moſt common mineralizer of metals, and therefore moſt of its combinations, with thoſe ſubſtances, muſt be ranked among the metallic ores. *Edit.*

[*b*] Of this kind is the *juan blanco*, which ſhould not be thought the ſame with *platina*, though it comes from the

SECT. 255. (153.)

b. Liver-coloured Marcaſite, *Pyrites colore rubeſcente.*

Its colour cannot be deſcribed, being betwixt that of the preceding marcaſite, and the azure copper ore. When it is of a light colour, it is called in Swediſh *Tennbett*, or *Wattnkies*, but *Lefverſlag* when it is of a deeper colour. The iron prevails in this kind; it is therefore leſs fit to have ſulphur extracted from it, and alſo for the ſmelting of copper ores. It is found

1. Of a compact texture, from Nya Kopparberget, in the province of Weſtmanland.
2. Steel-grained, from Stollberget in Weſtmanland.
3. Coarſe-grained, from Weſterſilfverberget in Weſtmanland.

ſame mines. The cryſtallized or poliſh-bearing ſpecies are known by the name of *marcaſites.* In Hungary, there are ſome which are pretty rich in gold; in the Moder-mine, near Shemnitz, they held ſixteen denari. *Brun.*

SECT. 256. (155.)

Various Combinations of Sulphur, *with* Iron *and other* Metallic Subſtances.

Sulphur with iron and copper, *yellow* or *marcaſitical copper ore.* (See Sect. 198. *of the Author.)*

Sulphur with iron, ſilver, and lead. *Potters lead ore. (See Sect.* 189. *of the ſame.)*

Sulphur with iron and zinc, *mock lead, black jack,* or *blende. (See Sect.* 229. *of the ſame.)*

Sulphur with iron and arſenic, *arſenical pyrites. (Sect.* 243. *of the ſame.)*

Sulphur with iron and cobalt. *(See Sect.* 250 *of the ſame.)*

Sulphur with iron and biſmuth. *(Sect.* 225. *of the ſame.)*

Sulphur with iron and nickel. *(Sect.* 256. *of the ſame.)*

Sulphur with iron and gold, pyritical gold ore. *(See Sect.* 166. *of the ſame.)*

SECT. 257. (156.)

Other Combinations of Sulphur, *with* Silver, Copper, *and other* Metallic Subſtances.

Sulphur with ſilver, *glaſs ſilver ore* [*a*]. *(See Sect.* 169. *of the Author.)*

Sulphur with copper, *grey* or *vitreous copper ore. (See Sect.* 197. *of the ſame.)*

Sulphur with lead, *Potters lead ore. (See Sect.* 187. *of the ſame.)*

Sulphur with biſmuth. *(See Sect.* 224. *of the ſame.)*

Sulphur with quickſilver, *cinnabar. (See Sect.* 218. *of the ſame.)*

Sulphur with arſenic, *Orpiment*, *Realgar. (See Sect.* 241. *of the ſame.)*

[*a*] At *Ramelsberg*, and in the *Hartz*, ſulphur is extracted from the ſulphureous ores of ſilver and lead, mixed with pyrites, by ſublimation, during the terrefaction of theſe ores. This forms *crude ſulphur*, which is purified by a ſecond ſublimation. But in *Bohemia* and *Saxony* it is obtained by immediate diſtillation from pyrites, and afterwards purified by ſublimation in cloſe veſſels. Moſt of the ſulphur uſed here comes from Italy. *Kirwan.*

SECT.

SECT. 258. (161.)

Mineral Phlogiſton mixed with Metallic Earths.
Phlogiſton minerale metallis impregnatum.

This is not found in any great quantity.

In regard to its external appearance, it reſembles pit coal; and the fat ſubſtance contained in it, at times, partly burns to coal, and partly volatilizes in a calcining heat.

The only known varieties of this kind are,

A. Minera cupri phlogiſtica.

When it has been inflamed, it retains the fire, and at laſt burns to aſhes, out of which pure copper can be ſmelted. It is found in Sladkierr's Grufva in the province of Dal, and at Biſperg's Klack, in the province of Dalarne.

B. Minera ferri phlogiſtica.

This is not very different in its appearance from the pit-coal or foſſil pitch; but it is ſomewhat harder to the touch: there are two varieties of this ſpecies:

1. Fixt in the fire, *Minera ferri phlogiſtica fixa.*

Expoſed to a calcined heat, it burns with a very languid though quick flame: it preſerves its bulk, and loſes only a little of its weight. It yields above 30 per cent. of iron.

a. Solid, reſembles black ſealing-wax.

39813

It is found in the liver-coloured marcaſite (Sect. 252), in Waſkberget, at Norrberke, in Weſtmanland.

b. Cracked, and friable, from Finnberget, at Grythyttan, in Weſtmanland.

2. Volatile in the fire, *Minera ferri phlogiſtica volatilis.*

This is unalterable in an open fire, either of charcoal in a furnace, or even upon a piece of charcoal with the flame of the blow-pipe: but, under a muffel, the greateſt part of it volatilizes, ſo that only a ſmall quantity of calx of iron remains. It is found,

a. Solid, from Kronprint's Shurff, at Kongſberg, in Norway.

b. Cracked, from the pariſh of Quiſtbro, in the province of Nerike.

This laſt kind leaves more aſhes: theſe aſhes, when farther expoſed to the fire, become firſt yellowiſh-green, and afterwards reddiſh-brown, when, beſides iron, they then alſo diſcover ſome marks of copper. It has, however, not been poſſible to extract any metallic ſubſtance from them; the effects of the load-ſtone, and the colour communicated to the glaſs of borax, having only given occaſion to this ſuſpicion.

See the end of Sect. 239. (*or* Sect. 150, *of the* Author.)

SECT.

SECT. 259. (162.)

Obſervation on Bitumens.

That ſubſtance, which the chemiſts call *Phlogiſton*, or an *inflammable principle*, exiſts in moſt of the mineral bodies, though often in ſo ſmall a quantity as not to be perceived; and therefore I have here only enumerated thoſe kinds, in which it exiſts as a principal or very ſenſible character; as, for inſtance, in the fœtid ſpar, or ſwine ſtone.

I do not myſelf know the ſubſtance in its ſimple ſtate, which I call a *mineral phlogiſton* [*a*], ſince the ambergriſe and the rock-oil are nothing elſe than compoſitions which cannot be perfectly decompounded; and are not, beſides, to be extracted from coal, ſulphur, &c. which, notwithſtanding, contain an inflammable ſubſtance. It ſeems as if a great part of this claſs were originally generated from the animal and vegetable kingdoms; ſo that they have been firſt an *humus ater* or mould, with which a vitriolic acid has afterwards been mixed; and that they have been beſt able to retain this phlogiſton, when they have been covered and

[*a*] We may ſay, however, at preſent, that phlogiſton may be produced almoſt pure, after the new obſervations and diſcoveries that have been made of late on the aeriform ſubſtances. *See Note* [*a*] *to Sect.* 229. *Page* 441.
The Editor.

preſſed together by another earth; the *coal*, *coal ore*, and *peat turf* (Sect. 193 of the Author), give ſome hints or reaſons for this ſuppoſition.

The generation of ſulphur and marcaſite, requires no phlogiſton out of any of the kingdoms of Nature in preference to the other; for the phlogiſtons throughout all nature are equally fit to compoſe it [*b*].

It is a ſublime ſubject for philoſophers to enquire, how far fire, phlogiſton, and electricity, have an affinity with, or dependence on, one another; but as they yet want that light in this matter, which they wiſh to have, I hope to be excuſed for not mentioning any theories on the ſubject.

This claſs is of great uſe in medicine; for inſtance, the ambergriſe, the ſalt of the yellow

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[*b*] All foſſils, containing phlogiſton in ſuch abundance, that, under proper management, are inflammable, have been referred to this third Claſs of Minerals. The Orders are obviouſly very few; and, accurately ſpeaking, there is only one Genus. But ſince phlogiſton is ſo very ſubtle, as not by itſelf alone to become the object of our ſenſes in its pure ſtate, it has been adviſable to conſider its more ſimple combinations as Genera: and this has long been done, ſo far as reſpects the metals, by univerſal conſent.

The name of *Sulphur* may certainly be given to any *acid*, coagulated by *phlogiſton* into a ſolid form; and, if metals conſiſt of certain radical *acids*, ſaturated with *phlogiſton*, as is highly probable, and, with reſpect to *arſenic*, and two others, is indubitably proved (See the Note to page 510.), then metals ought to find a place in this Claſs. But until this theory be eſtabliſhed by numerous experiments, we have only ranked, under this head, the compounds which have not a metallic nature. *The Editor, chiefly from* Bergman's Sciagraphia, Sect. 132. *and following.*

amber, the rock-oil, the aſphaltum, and the ſulphur. The rock-oil and ſulphur are uſed in fireworks; the aſphaltum [c] by the cement-makers, and the yellow amber is uſed by the varniſhers and painters, [d].

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[c] The firſt Engliſh Edition ſays, that the Aſphaltum is made uſe of by *watch-makers*; but this muſt be a real miſtake, as it is obviouſly abſurd to ſuppoſe that any advantage can be reaped from any oily ſubſtance, which ſoon volatilizes, and is even corroſive itſelf: when the greateſt difficulty our watch and chronometer-makers labour under, is to find a very thin and fluid oil, which may be applied to the pivots of the wheels, and to the palets of the eſcapements, without thickening, nor condenſing by cold, nor drying by length of time. Such kind of oil is a great deſideratum in watch making, and the aſphaltum has quite the oppoſite qualities. It may, however, be uſefully employed in making a durable cement of the beſt ſort, as Bomare aſſerts. *The Editor.*

[d] The coals in particular are of the greateſt conſequence for œconomical uſes; and happy therefore are thoſe countries which have a ſufficient quantity of them; ſince they may be employed as fuel to almoſt every purpoſe, as is plainly proved in England. *Engeſtrom.*

CLASS

CLASS IV.

Metallic Subſtances.

SECT. 260. (163.)

General Properties of Metals [*a*].

METALS are thoſe mineral bodies, which, with reſpect to their volume, are the *heavieſt* of all hitherto known bodies. Some

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[*a*] Thoſe metals, which in a calcining-heat loſe their phlogiſton, and conſequently with that the former coherency of their particles, are called *imperfect*, as *tin*, *lead*, *copper*, and *iron*, and all the *ſemi-metals* (of which more hereafter): notwithſtanding which they may be *malleable*. But thoſe which cannot be deſtroyed in the fire alone, are called *perfect*, as *gold*, *ſilver*, and *platina del Pinto*. Nevertheleſs, the metals have commonly been conſidered more with regard to their *malleability* than to their *fixity* in the fire, and are therefore divided into,

A. Malleable, which are called *metals*; and

B. Brittle, which are called *ſemi-metals*.

The *zinc* is, however, as a medium between theſe two diviſions, juſt as the *quickſilver* is between the *perfect* and *imperfect* metals; becauſe the *quickſilver* may indeed be ſo far deſtroyed in the fire, that its particles are ſeparated

Some of them are *malleable*; and ſome may be

ſeparated during their volatilization; nevertheleſs, every one of them, even the minuteſt, retains the phlogiſton united with it. *The Author.*

Zinc and arſenic ſtand alſo, as it were, upon the borders betwixt *metals* and *inflammables*; for theſe, in proper circumſtances, burn with a very evident flame.

All the metallic ſubſtances contain phlogiſton, and when, to a certain degree, deprived of it, fall into a powder like an earth; but their attractions for phlogiſton are different.

Moſt of them, when melted in a common way, and expoſed to the air, have an earthy cruſt formed upon the ſurface, which cannot again be reduced to metal without the addition of ſome inflammable matter. The *baſe metals* have this property.

But the *noble metals*, viz. *platina*, *gold*, and *ſilver*, are ſo firmly connected to the phlogiſton, that they never calcine under fuſion, however long continued; and, after being changed into a calx in the liquid way, when melted in the fire, they re-aſſume their metallic form, without any other phlogiſton than what is contained in the matter of heat.

Quickſilver holds a kind of middle place; for, like the *baſe metals*, it may be calcined, though not readily; and like the *noble* ones, it may be reduced by heat alone.

Bergman's Sciagr.

We may therefore reckon four *noble* or *perfect metals*; viz. *gold*, *platina*, *ſilver*, and *mercury*; becauſe, when calcined, they recover their phlogiſton, without the addition of any phlogiſtic ſubſtance.

But as *tin*, *lead*, *copper*, and *iron*, cannot be reduced without ſuch addition, theſe are called *Ignoble* and *Imperfect*, or *baſe metals*.

However, all theſe eight metals (even mercury, when ſolid) are *malleable* to a conſiderable degree, and are called *intire metals*. But

Biſmuth, *zinc*, *antimony*, *arſenic*, *cobalt*, *nickel*, *manganeſe*, *molybdena*, and *wolfram*, are ſcarce at all malleable, and hence they are called *Semi-metals*. Nevertheleſs, *zinc* and *purified nickel*, are more malleable than any of the other ſemi-

be *decompounded*; and, in a melting heat, be brought

ſemi-metals; ſo that we have four *perfect* or *noble* metals; four *imperfect* or *base*; eight *intire*; and nine *ſemi-metals*. Kirwan.

The various degrees of heat required, to reduce metals to a fluid ſtate, are ſeen in the following table, which was extracted, for the moſt part, by Dr. Withering, from the printed Treatiſes of the late celebrated Profeſſor Bergman. It exhibits, in a ſimple view: 1. The *ſpecific gravity* of each metal: 2. The *degree of heat* by Fahrenheit's ſcale, in which it melts: 3. The quantity of *phlogiſton* it requires for its ſaturation: and 4. its *attraction* to the ſame *ſaturating phlogiſton*. We muſt, however, obſerve, that if the ſecond column be compared with that of Wedgwood's thermometer, already mentioned in the Note to page 230 of this Mineralogy, their great diſagreements betray ſome fundamental error in the aſſumed data; as the degrees of heat, aſſigned by Mr. Wedgwood, for melting *gold*, *ſilver*, and *copper*, are more than quadruple of thoſe aſſigned by Bergman; and that for melting *iron* is more than *eleven* times greater; although they both nearly agree in the *red heat* of *iron*, which Bergman ſays to be 1050 degrees, and Wedgwood 1077. As far as I can judge, the fault lays in Mortimer's thermometer, which Bergman quotes with ſome diffidence (Sect. 197. of his *Sciagraphia*): probably the changes cauſed by heat, on this metallic thermometer, are in a much leſs increaſing proportion by intenſe fire, than thoſe indicated by the contraction of the *pure clay*, happily employed by Wedgwood in his thermometer. I have therefore added another column to this table marked *Wedgw.* with the degrees of the melting heats already aſcertained by this laſt thermometer, as being the neareſt to truth. The curious may fill up the vacancies whenever they pleaſe, as theſe new thermometers can now be had for three pounds ſterl. each, at the Inventor's Ware-houſe, London.

N. B. Metallic Thermometer of Mr. Crom. Mortimer, is compleatly deſcribed by himſelf, in the vol. of the *Phil. Tranſact.* for 1747, *p.* 684. *The Editor.*

METALS.

brought back again to their former ſtate, by the

METALS.	Specific Gravity.	Melting Heat. *Berg.*	Melting Heat. *Wedgw.*	Saturating Phlogiſton.	Attraction to ſaturating Phlogiſton.
Gold	19,640	1301	5237	394	1 or 2
Platina	21 000			756	1 or 2
Silver	10,552	1000	4717	100	3
Quickſilver	14,110	—40	—40	74	4
Lead	11,352	595		43	10
Copper	8,876	1450	4587	312	8
Iron	7,800	1601	17977	342	11
Tin	7,264	415		114	9
Biſmuth	9,670	494		57	7
Nickel common	7,000	1301		156	11
Nickel pure	9,000	1601		109	5
Arſenic	8,308				
Cobalt common	7,700	1450			
Cobalt pure		1601			
Zinc	6,862	699		182	11
Antimony	6,860	809		120	6
Manganeſe	6,850	very great		227	11

N. B. By *ſaturating phlogiſton*, Profeſſor Bergman means to expreſs the proportionate quantities taken away from each metallic ſubſtance, when diſſolved by means of acids, and of courſe reduced to a calciform ſtate. The laſt column only expreſſes their attraction to this part of their phlogiſton, not ſo that which ſtill remains united to them in a calciform ſtate. *Withering.*

The great ſimilarity between *metallic* and *inflammable* ſubſtances, has been mentioned in Note [*a*], to Sect. 228. p. 433. But metals in general are opake bodies, whoſe ſpecific gravity exceeds 5000, as the lighteſt of them are above ſix times heavier than an equal bulk of diſtilled water. They conſiſt of heavy, dull, brittle earths, combinable with phlogiſton, and whilſt ſo combined, poſſeſſing a ſhining appearance. *Kirwan* and *Bergman.*

Mr. Mongez remarks, that the following are the general properties of metals, when conſidered as *phyſical bodies*; viz. their *opacity*, great *ſpecific gravity*, *ductility*, *tenacity*, *cryſtalization*, *flavour*, and even *ſmell*, at leaſt in ſome of them.

It

the addition of the phlogiſton they had loſt in

It is from their *denſity* that their *gravity* and *opacity* proceed; this laſt being ſuch, that even reduced to the thinneſt plates, no rays of light can paſs through their particles, unleſs there remains an interſtice, or pore, quite free from the metallic ſubſtance. Gold leaf muſt, however, be excepted, which exhibits a fine green by tranſmitted light. *See Note* [*d*] *to Sect.* 261.

As to their *cryſtallization*, it has been found to take place, whenever they are pure, and left to cool very ſlowly by themſelves, after having been perfectly fuſed. *See* Journal de Phyſique, *for July* 1781, p. 74. The *flavour* and *ſmell* abovementioned, are very ſenſible in the reguline ſubſtances of *arſenic* and *antimony*, as well as in *lead*; *copper*, and *iron*. *The Editor.*

All metals are conductors of electricity; and more perfectly ſo than any other bodies, during their union with phlogiſton.

They are ſoluble either in nitrous acid, and in deplogiſticated marine acid, or in *aqua regia*; and are precipitable in ſome degree by cauſtic alkalies; and, except platina, by the Pruſſian alkali.

When dephlogiſticated, they communicate a tinge to *borax*, and to *microcoſmic* ſalt, or at leaſt render them *opake*.

They aſſume a convex ſurface, when melted; and even a globular form, if in a ſmall quantity; and though they mix, for the moſt part, with one another, whilſt fuſed, yet they refuſe to unite with unmetallic ſubſtances, even their own calces, iron only excepted, which does to its own calx *ſlightly dephlogiſticated*, and to *plumbago*. Nickel alſo, and ſome others, may contain *ſulphur* in their reguline ſtate.

Metals, when calcined, are capable of uniting with other calces and ſalts.

Three of the metallic calces have been found to be of an acid nature; viz. the *arſenical*, *molybdenic*, and *tungſtenic*, from which, by analogy, the nature of other calces may be conjectured.

The phlogiſton, contained in metals, is in a pure ſtate; *viz.* without *water* and *aerial acid*, with which it is invariably accompanied in all other compounds, except *acid airs* and *ſulphur*. The Editor, chiefly from *Kirwan*.

When

their decompoſition.

When metallic ſubſtances are naturally found in the earth, united to their full ſhare of phlogiſton, and conſequently poſſeſſing their peculiar properties, they are called *native*.

But when they are found more or leſs deprived of their phlogiſton and of their properties, combined with other ſubſtances, they are then called *mineralized*. This is the moſt common ſtate of the mineral kingdom. The ſubſtance ſo combined with them is called the *Mineralizer*; and the whole is called *ore*; by which name are alſo diſtinguiſhed the *earths* and *ſtones*, in which metallic ſubſtances are contained.

But if both metallic ſubſtances are mixed together in their *metallic* or *reguline* form, without the loſs of *phlogiſton*, they are then ſaid to be *alloyed*.

When the *mineralizer* is of a *ſaline nature*, and renders the metallic combination ſoluble in leſs than 20 times its weight of water; the compound is ranged among *ſalts*. Thus the *vitriols* of *iron*, *copper*, and *zinc*, are rather claſſed with *ſalts*, than with *ores*.

The commoneſt mineralizers are *ſulphur*, *arſenic*, and *fixed air* (or *aerial acid*). The leaſt common are the *vitriolic* and the *marine acids*. The *phoſphoric* has been found only in two inſtances; *viz.* united to *lead*, diſcovered by Gahn; and to *iron* in the *ſiderite*, as Mr. Meyer believes.

Thoſe metallic ſubſtances, mineralized by *aerial acid*, are called *Calciform ores*. The Editor, chiefly from *Kirwan*.

If the new doctrine of Mr. Lavoiſier and his followers, who pretend that calces of metals are a compound of *dephlogiſticated*, or *vital air*, with the metallic ſubſtance, were any ways probable; all *calciform ores* ſhould produce this *vital air*, inſtead of *aerial acid*, when they are reduced to their metallic-form, which is not the caſe; neither ſhould all the *baſe metals* and *ſemi-metals*, abſolutely require the mixture of ſome phlogiſtic ſubſtance, for being reduced from the ſtate of calces to their metallic form, which otherwiſe would be quite uſeleſs, if their reduction ſimply conſiſted in their ſeparation from the *vital* (the dephlogiſticated) *air*. See the Note [*a*] to page 442.

The Editor.

ORDER

ORDER THE FIRST.

Noble or Perfect Metals.

SECT. 261. (164.)

Gold; *Aurum: Sol Chymicorum*, Lat. *Or*, French.

THIS ſubſtance is eſteemed by mankind as the principal and firſt among the metals; and that partly for its ſcarcity; but chiefly for its following qualities.

1. It is of a yellow ſhining colour.
2. It is the heavieſt of all known bodies, its ſpecific gravity to water being as 19,640 to 1000.
3. It is the moſt tough and ductile of all metals. One grain of it may be ſtretched out ſo as to cover a ſilver wire of the length of 98 *Swediſh ells*, by which means $\frac{1}{705600}$ of a grain becomes viſible to the naked eye [*a*]

4. Its

[*a*] According to Paucton, 98 Swediſh ells make only 63,66 Engliſh yards, (2291,76 Engliſh inches); but, as the *hundredth part* of one inch is viſible enough to the naked eye; and we may conceive, that every one of theſe minute cylinders can be ſeen by rays of light reflected from ſix different parts, at leaſt, of its ſurface, the Noble Author might ſafely aſſert,

4. Its softness comes nearest to that of lead, and

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assert, that above one millionth part of a *grain* of gold; (*viz.* $\frac{1}{1375056} = \frac{1}{229176 \times 6}$), is visible to the naked eye.

But Wallerius goes still further, unless there be some error in the press; for he says (page 352. vol. II. edit. 1778), *purum etenim aurum pondere unius grani ad* 500 *ulnarum longitudinem extendi posse.*

Halley, quoted by Apligny (p. 152. of his Treatise on Colours), says, that *one ounce* of gold (=576 grains) is enough to cover 48 *ounces* of silver, which may be drawn so fine, without leaving the silver naked, that 6 feet of it shall not weigh above *one grain*. Then *one grain* of gold may cover a wire of 294 feet, or 98 yards; and $\frac{1}{10584}$ of one grain, may cover $\frac{1}{3}$ of one inch, which divided into 10 parts, every one of them will be very visible without any magnifier: from thence it is evident, that $\frac{1}{1050840}$ of *one grain* of *gold* is very discernible to the naked eye, in each single side of its surface.

Boyle, quoted also by Apligny, says, that one grain and a half of gold, may be beaten into 50 leaves of one inch square; which, if cut by parallel lines, drawn at the distance of $\frac{1}{100}$ of an inch from one another, will produce 25 millions (25000000 = 5000 × 5000) of little squares, very discernible to the naked eye.

The ductility of gold is such, that it may be extended, by the hammer, 159092 times its surface.

I am informed, by an intelligent gold-beater in England, that the finest gold leaf is that made in new skins, and must have an alloy of 3 *grains* of copper to the *ounce troy* of pure gold, or else it would be too soft to pass over the irregularities of the skins. He affirms, that 80 books, or 2000 leaves of gold, each measuring 3,3 square inches; *viz.* each leaf containing 10,89 square inches (=3,3 × 3,3), weigh less than 16 *dwts*, or 384 *gr.* (=16 × 24 *gr.*). Each book, therefore, (or 25 leaves = 272,23 square inches) weighs less than 4,8 *gr.* ($= \frac{384}{80}$); and each *grain* will produce 56,718 square inches ($= \frac{10,89 \times 25}{48 \text{ gr.}}$).

and conſequently it is but very little elaſtic [*b*].

5. It is fixed and unalterable in air, water, and fire, becauſe it does not eaſily part with its phlogiſton; its liquid menſtruum (7) being only made by art.

It has, however, according to Homberg's experiments, when expoſed to Tſchirnhauſen's burning-glaſs, been found partly to volatiliſe

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Now one cubic inch of pure gold weighs 10,359 *ounces Troy*, or 4972,32 *gr.* (480 × 10,359 *oz.*); and of courſe, *one grain* of gold, when beaten into a ſquare ſurface of one inch, only occupies, by its thickneſs, the $\frac{1}{4972,32}$ part of the inch ſide of this cube; but as each grain produces above 56,718 leaves of this dimenſion, it is evident that the thickneſs of each leaf is in fact leſs than the $\frac{1}{56,718 \times 4972,32}$, or $\frac{1}{282020}$ part of an inch.

By the above treatment, the 16 *dwt.* of gold are made to cover 151,24 *ſquare feet*; ſince the 16 *dwts*, or 384 *gr.* produce 21779,712 (=384 × 56,718) ſquare inch leaves, 144 of which make a *foot ſquare*. But, when ſilver is covered with gold, and drawn into a wire, the gold may ſpread over its ſurface 12 times more, without leaving any ſpace uncovered, that may be ſeen, even with a deep magnifier; thus, 16 ounces of gold, which, if in the form of a cube, would not meaſure *one inch* and *one quarter* on its ſide, will compleatly gild a quantity of ſilver wire ſufficient to circumſcribe the whole globe of the earth. *The Editor*, from *Wallerius*, *Reaumur*, *Nicholſon*, *Paulton*, &c.

[*b*] Gold is more elaſtic than *lead* or *tin*; but it has leſs elaſticity than *iron* or *copper*. *Fabr.*

However, when hammered, it becomes harder. *Bomare.*

It has not only a *ductility* greater than any other metal, but the *tenacity* or *coheſion* of its particles exceeds that of others. A wire of gold, not thicker than the *tenth* of an inch of the *Rhine foot*, can hold 500 pounds weight, without breaking. *Wallerius* and *Bomare.*

in

in form of ſmoke, and partly to ſcorify; but this wants to be farther examined. (*See Sect.* 264.) It is alſo ſaid that gold, in certain circumſtances, and by means of certain artifices in electrical experiments, may be forced into glaſs; and that on this occaſion it becomes *white*, leaving a *black duſt* behind it [*c*], which, if ſo, confirms certain other chemical experiments; viz. that gold can, together with its colour, loſe ſomething of its phlogiſton, and yet retain its heavineſs, ductility, &c.

6. When melted, it reflects a bluiſh-green colour from its ſurface [*d*].

7. It

[*c*] This muſt be a miſtake of the Engliſh Editor, unleſs the author has been himſelf groſſly miſinformed. It is true, that fine gold is intimately (though not uniformly) united to, or forced into, a glaſs ſurface, by the electrical exploſion; even ſome part of it becomes calcined, producing fine purple ſpots on the glaſs, as I have ſeen ſometimes: and Dr. Prieſtley aſſerts the ſame, in his *Hiſtory of Electricity*; but the metal never turns *white*, nor does it leave behind any *black duſt*, if it is pure. *The Editor.*

[*d*] When gold is expoſed to fire, it becomes red-hot long before it melts: in this caſe it has a brilliant greeniſh colour, inclining to blue; and, when cold, cryſtalliſes into quadrilateral pyramids. *Mongez.*

I have ſaid, in the *note* to *page* 510, that gold-leaf exhibits a fine green colour, by tranſmitted light, a fact which every one may eaſily verify; and the ſame phenomenon takes place, when the metal is ignited, as juſt now obſerved. The green light is tranſmitted in both caſes, ſince all reflected colours are produced by the tranſmiſſion of light, as the ingenious Philoſopher Mr. Delaval has lately diſcovered and demonſtrated,

7. It diſſolves in *aqua regia*, which is compoſed of the acids of ſea-ſalt and nitre; but not in either alone, nor in any other ſolution of ſalt or acid whatſoever. [*e*].

8. When

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in his very elaborate Treatiſe upon this ſubject, *inſerted in the ſecond vol. of the* Memoirs, *publiſhed in* 1785, *by the* Philoſophical Society of Mancheſter. Sir Iſaac Newton, in his Opticks (page 162, edition of 1730), accounts for that phenomenon, ſaying, that *gold foliated, and held between the eyes and the light, looks of a greeniſh blue; and therefore,* ſays he, *maſſy gold lets into its body the blue rays, to be reflected to and fro within it, till they be ſtopped and ſtifled, whilſt it reflects the yellow outwards, and thereby looks yellow.* It is therefore in the two above caſes, that ſome of the *blue* rays are tranſmitted along with the *yellow* ones, and both together appear of a *green bluiſh colour*, ſince every one knows, that blue and yellow together make a green colour. If gold be expoſed to the joined rays of light, except only the *yellow* ones (which we ſuppoſe ſtopped after they were ſeparated by a priſm), it only looks *white* like *ſilver*, *which ſhews*, ſays Sir Iſaac Newton (p. 166.), *that its* yellowneſs *ariſes from the exceſs of the* intercepted rays *tinging that* whiteneſs *with their colour, when they are let to paſs.*

It is a pleaſing obſervation to look with a deep magnifier on various pieces of *gold*, *ſilver*, and *Dutch* (copper) *leaf*, between the eye and the ſun-ſhine. The particles of *Silver* are ſeen in the form of oblong dark lumps, with ſome interſtices, like net-work, between them: thoſe of the *copper leaf* are more numerous and more regularly diſtributed; but the particles of the *gold leaf* appear like little green ſemi-tranſparent and ſimilar particles, joining between themſelves by nearly diaphanous joints, as if they were forced to flatten in their edges, rather than they would break their mutual union between one another. *The Editor.*

[*e*] Gold is not only diſſolved in *aqua regia*, but alſo in the *dephlogiſticated marine acid.* As to the pure concentrated

8. When mixed with a volatile alcali and a little of the acid of nitre, by means of precipitation out of *aqua regia*, it burns off quickly, in the leaſt degree of heat, with a ſtrong fulmination. (*See Sect.* 264.)

9. It is diſſolved, *in formâ ſiccâ*, by the liver of ſulphur, and alſo ſomewhat by the glaſs of biſmuth [*f*].

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nitrous acid, it rather tears, or corrodes the particles of gold, than makes with it any real ſolution, ſince it is enough to ſhake it, to free the metallic particles from the acid, and cauſe them to fall to the bottom, as *Wallerius* and *Mongez* aſſert. *See Note* [*y*] *to page* 289. The Editor.

By diſtilling vitriolic acid from off manganeſe, an acid is obtained, which alone is capable of diſſolving *gold*, *ſilver*, and *mercury*, very readily, as Dr. Crell affirms in a letter to Mr. Darcet. Journ. de Phyſique, Oct. 1785, p. 297.

The ſolution of gold in *aqua regia* is accompanied with effervescence; is of a yellow colour more or leſs deep; tinges animal ſubſtances of a deep purple colour, and corrodes them. Its cauſticity is conſiderable: after a proper evaporation, it gives yellow cryſtals; if theſe are diſtilled, produce a fine red liquor, to which the Alchymiſts gave the name of *Red Lion*. Fourcroy.

[*f*] Neither *ſulphur*, nor *fixed alkali*, have any action on gold; but the *liver of ſulphur*, which is a compound of both, can diſſolve it in the *dry-way*; ſo that if a proper quantity of gold leaves is put in a crucible, together with *liver of ſulphur*, and it is melted in a briſk fire, the gold is thoroughly diſſolved; and if the whole is diluted in water, the gold will be kept in the ſolution, and even paſs through the filtre along with it.

Gold, as well as ſilver, is ſo much attenuated by biſmuth, that it may be advantageouſly employed in their coppellation, as Keir aſſerts in his notes to *Macquer's Dictionary*; but Poerner, quoted alſo by the ſame Author, in his ſecond edition, is of a contrary opinion. *The Editor.*

10. It is not carried away by the antimony during the volatiliſation of that ſemi-metal, and is therefore conveniently ſeparated from other metals by the help of crude antimony, in which proceſs the other metals are partly made volatile, and fly off with the antimony, and partly unite with the ſulphur, to which the gold has no attraction, unleſs by means of ſome uniting body, or by a long digeſtion [g].

11. The phoſphorus is ſaid to have ingreſs into gold [h].

12. If mixed with a ſmall proportion of ſilver, platina, copper, iron, and zinc, it preſerves its ductility tolerably well; but,

13. When mixed with tin it becomes very brittle; and it attracts likewiſe the ſmoke of

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[g] Antimony is uſed alſo to refine gold from its alloy, as it attenuates and carries off all other metallic ſubſtances mixed with it, without excepting the ſilver; whilſt lead leaves this laſt behind, and even adds ſome of its own to the gold. *Pauëton*, p. 659.

[h] Gold, reduced into thin leaves, is not acted upon by the phoſphoric acid in the *humid way*, though the fire be urged till luminous decrepitations take place; but when it paſſes that point, which ſeparates the *humid* from the *dry way*, Mr. Margraff obſerved, that ſome purple ſcoria were formed, which is an indication that this concrete acid had partly calcined the gold during its fuſion. *Elements de Chymie de Dijon, Vol. III. p.* 131.

Beſides this, a drop of the phoſphoric acid on the ſolution of gold by *aqua regia*, precipitates the metal in its revived ſtate, as aſſerted by the ſame Academicians of Dijon. See Note [b] to p. 314. *The Editor.*

that

that metal, ſo as to be ſpoiled, if melted in an hearth where tin has been lately melted [*i*]. And this is perhaps the reaſon why gold becomes brittle, and of a paler colour, when melted in a new black lead crucible [*k*].

14. It requires a ſtrong heat before it melts, nearly as much, or a little more than copper.

15. It mixes or amalgamates readily with quick-ſilver [*l*].

16. It is not diſſolved by the glaſs of lead, and therefore remains on the cuppel.

In conſequence of theſe its principal qualities, it ſeems as if gold could never be found in the earth, but in a native or pure ſtate; there are, however, ſeveral inſtances where it has been found diſſolved or mineraliſed [*m*]

[*i*] The fumes only of a ſingle grain of tin are capable of rendering hard eight ounces of gold; but it eaſily recovers its malleability by being melted on the fire. *Wallerius* and *Bomare's* Mineralogy.

But when gold is mixed with *arſenic*, *cobalt*, *nickle*, *biſmuth*, or with the *regulus* of *antimony*, it only loſes great part of its malleability; and when in a certain proportion, it may be calcined and vitrified with them. *Fabroni*.

[*k*] The Author ſuppoſed (in the firſt edition) that *black-lead* contained *tin*; but late experiments ſhew, that it does not contain any. *See Sect.* 231. If the fact, aſſerted by the Author, is conſtant, it muſt proceed from ſome other cauſe. *The Editor*.

[*l*] There is a very peculiar and ſtrong attraction between gold and mercury; and it ſeems to be greater than that between the *load-ſtone* and *iron*. Wallerius.

[*m*] Thoſe inſtances, mentioned by the Noble Author, as proofs of gold being found *mineraliſed*, are diſputed by ſome eminent Mineralogiſts, though upon doubtful grounds, as will appear by the Sect. 263. *The Editor*.

SECT. 262. (165.)

A. Native Gold, *Aurum nativum.*

Is in its metallic form *commonly* pure; and in this ſtate moſt part of this metal uſed in the world is found [*a*]. With reſpect to either,

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[*a*] This muſt be a miſtake of the editor of this work, as it is well known that native gold is generally found impure. Bergman openly acknowledges not to know that it has ever been found perfectly pure: and Kirwan only allows that it is ſeldom found ſo, being generally alloyed with *ſilver*, *copper*, or *iron*, or all three. As to the gold, commonly uſed in jewels and other objects of luxury, every one knows that it is purpoſely debaſed, by the artiſts, with copper or other metals; and of late it has been employed in various pieces of jewellery, forming ornaments of various colours; as a great alloy of *ſilver* (viz. one-third part) gives it a ſhade of a green colour; a ſimilar quantity of copper, a *reddiſh* one; a mixture of arſenic, or filings of ſteel, in the proportion of one-fourth part, gives it a *blueiſh* caſt; ſo that having the *yellow* naturally in the pure gold, and the *white* in pure ſilver, the jewellers have almoſt all the colours to diverſify their work.

Even in the currency of money, there is none coined out of pure gold, which, by common agreement, is called *gold of 24 carats.* The gold coin of England, France, and Portugal, only contains 22 parts of *pure gold*, and 2 of alloy; *viz.* it is only of 22 *carats*, in the common ſaying; that of Spain is but of $21\frac{19}{32}$ carats; but the *ducat* of Holland is of $23\frac{23}{32}$ carats; and the *zecchino* of Venice, of $23\frac{23}{32}$ carats: this laſt is the pureſt gold coin, as it ſeems, of Europe at leaſt. *The Editor, chiefly from* Pauctou's Metrologie.

the

the figure or the quantity in which it is found in one place, it is by miners divided into [*b*].

1. Thin ſuperficial plated or leaved gold, which conſiſts of very thin plates or leaves, like paper [*c*].
2. Solid or maſſive, is found in form of thick pieces [*d*].

3. Cryſ-

[*b*] Wallerius diſtinguiſhes native gold by the following 6 forms; *viz.*

1. In *ſolid* maſſes; found in *Hungary*, *Peru*, and *Tranſylvania*.
2. In a *granular* form, found in the Spaniſh Weſt-Indies.
3. In a *vegetable form*, like branches or twigs of plants.
4. In a *druſic* figure, as if compoſed of *groups*, or cluſters of ſmall particles united together; found in Hungary.
5. In a *ſuperficial* form, compoſed of thin plates, or thin pellicles covering other bodies, found in Siberia.
6. And cryſtalliſed, found in *Hungary*.

Finally, Mr. Daubenton, in his *Methodical Tables of Minerals*, enumerates 8 ſorts of native gold; *viz.* 1. in powder. 2. in grains. 3. in ſmall ſpangles. 4. in maſſes or lumps. 5. in filaments. 6. in branches like vegetables. 7. in lamells; and 8. in octoedral cryſtals.

The ſame Natural Hiſtorian ſays alſo, that gold, in its reguline ſtate, is either 1. formed into angular cryſtals, compoſed of yellow octoedres; or 2. into irregular yellow maſſes, which, being broken, ſhew a granular ſubſtance. *The Editor.*

[*c*] Native gold in a form of leaves, is always cryſtalized on its ſurface.

Theſe cryſtals are very ſmall: with a microſcope, one may diſcover their triangular pyramidal form.

In Tranſylvania, I have procured a ſpecimen of cubic native gold, but never ſaw it any where elſe.

The cryſtals on the ſtone, are of the ſize of ſmall hemp-ſeeds. *Brun.*

[*d*] Gold is in general more frequently imbedded and mixed with quartz, than with any other kind of ſtone; and the quartz in which the gold is found in the Hungarian gold mines

3. Cryſtalliſed, conſiſts of an angular or criſtalline figure [*e*].

4. Waſh gold, or gold-duſt, is waſhed out of ſands, wherein it lies in form of looſe grains and lumps [*f*].

SECT.

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mines, is of a peculiar mild appearance. All other ſorts of ſtones, however, are not to be excluded, ſince gold is likewiſe found in ſome of them; for inſtance, in lime-ſtone (Sect. 9.) in Adolph Fredrik's Grufva, at Adelfors, in the province of Smoland; in Hornblende (Sect. 137.), in Baſtnas Grufva at Riddarſhyttan, in the province of Weſtmanland; not to mention ſeveral foreign gold-mines.

The greateſt quantity of gold is imported into Europe from Chili and Peru, in America; and a little from China, and the coaſt of Africa. The chief European gold-mines are thoſe of Hungary, and next to them that of Saltzburg. Beſides theſe, there are ſome others of leſs conſequence; among which the gold-mines at Adelfors in Smoland deſerve to be taken much notice of, not only on account of the veins already worked, but alſo in regard to the vaſt tract of land, within which new veins are daily diſcovered. The ſilver, from the mines of Oſterſilvarberget, in the province of Dalarne, contains from 4 to 7 grains of gold in the mark. Some native gold has likewiſe been found in Swappawari, above Tornea in Lapland, and in Baſtnas, near Riddarſhyttan, in Weſtmanland. *The Author.*

[*e*] The cryſtalline form of gold is the *octoedral rectangular one*, for the moſt part; but it is alſo found in the form of ſmall druſical cryſtals: ſometimes branched like *dendrites*, and ſometimes ſolitary. There are alſo cubic cryſtals of this metal (Note *c*), all which evidently ſhow how little can we truſt to the teſt of cryſtalline forms, in order to diſtinguiſh mineral ſubſtances from one another. *The Editor from* Wallerius, Romé de l'Iſle, &c.

[*f*] Wallerius diſtinguiſhes this kind of gold-ore by the various earths and ſubſtances with which it is mixed; and by the different colours it aſſumes from them as the *ochreous*, *margaceous*,

margaceous, and *argillaceous* gold ores; those mixed with *red granatic sand*, or with *black* and *lead-coloured sand*, &c.

Native gold is found also *separate*, from any matrix in lumps, or visible grains mixed with sand; and in this state it is found in many rivers of *Europe*, *Africa*, and elsewhere, or visibly dispersed through large masses of sand, particularly the yellowish red, or violet; and, in this state, it is so generally diffused through all species of earth, though in exceeding small quantities, that Mr. *Bergman* thinks it more universally found than any other metal, except iron. If 100 pounds of sand contain 24 grains of gold, it is said the separation is worth attending to; but in *Africa* 5 pounds of sand often contain 63 grains of gold, or even more; the heaviest sand, which is often black or red, yields most. In *Hungary*, 10,000 pounds of sand yield but 10 or 12 grains of gold; it was extracted, but with loss. *Born's Letters from Hungary*, quoted by *Kirwan*.

Most great rivers carry gold with them; even such as do not take their rise in those mountains where gold is found; it is therefore no wonder, that all rich gold-mines enrich their rivers with this metal.

The river *Avanyos*, in Transylvania, affords subsistence to upwards of 700 gipsy families, who collect the gold from it.

In Brasil the gold is found in so great abundance, that their torrents are often driven, with very considerable labour and expence, to new beds, in order to gather the gold there deposed by the running waters. But it is also found there mingled within the earth in various shapes and forms.

In Peru gold is found with a stony matter, not well known, and a red earth, from which it is there extracted by amalgamation with mercury. *The Editor, chiefly from* Kirwan.

The celebrated Naturalist, Mr. Pallas, speaks in the Account of his Tour through Siberia, of three gold mines that are worked there, near the river Pyschma, in which 500 men are employed. The gold is found in a powdery form, and also in thin small plates, or leaves. Sometimes kernels, or lumps of a spongy texture, and very light, are met with, in which a good quantity of gold-dust is loosely contained. The ore it found in a white clay, though, for the most part, it is of a grey yellowish colour, intermixed with mica. An argill, of a fine red colour, is also found in these mines. It was near

them

SECT. 263. (166.)

B. Mineralized Gold, *Aurum mineraliſatum.* This is an ore, in which the gold is ſo fa[r] mineraliſed, or enveloped by other bodies, as not to be acted on by the aqua regia.

1. Mineraliſed with ſulphur, *Aurum ſulphur[e] mineraliſatum* [*a*].

2. Mineraliſed

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them that the red lead-ore, deſcribed by Lehemah, was diſcovered. But theſe Siberian mines do not ſeem to produce above 400 marks of gold in the year, and could not pay the expences of being worked in a leſs cheap country than Siberia. *See Journal de Phyſique for* June 1783. *The Editor.*

Wolkemann, quoted by le Camus, aſſerts, in his *Soterraneous Sileſia*, that gold is alſo found, ſometimes in veins, running through beds of coals. *Journ. de Phyſique, for March* 1779, *poge* 183.

And Mr. Eller of Berlin, had, in his Collection, an ore, which contained *gold, ſilver, iron*, and *quickſilver*, cloſely united together in the ſame maſs. Watſon's Chemical Eſſays, Vol. IV. p. 157.

[*a*] Since gold and ſulphur have no attraction to one another; many have inſiſted, that gold never can be found in marcaſite, or thoſe ores which contain ſulphur: but ſince we know by experience, that gold can be melted out of the above-mentioned Ores, although they have been previouſly digeſted in *aqua regia*; and that gold likewiſe enters into their ſulphurated regulus; there is the greateſt reaſon to believe that a third ſubſtance, which here is a metal, muſt neceſſarily have, by its admixture, enabled the ſulphur to unite with a certain quantity of gold. Scheffer has given upon this ſubject ſome very curious and uſeful obſervations, in his Hiſtory of the Refining of Metals, inſerted in the Tranſactions of the Academy of Sciences at Stockholm. It is very remarkable, that the Mine-

Maſter

2. Mineraliſed by means of iron. *Aurum ſulphure mineraliſatum mediante ferro.*

Marcaſitical gold ore. *Pyrites aureus.*

It is found at Adelfors, in the province of Smoland; and contains one ounce of gold, or leſs, in an hundred pounds [*b*].

3. Mineraliſed

Maſter Henckel, author of that excellent Treatiſe *de Appropriatione*, ſhould be ſo obſtinate in denying that marcaſite could contain a diſſolved gold.

It is, however, by no means hereby intended to confirm the credulous in their opinion, that the marcaſites in general contain more gold than what true metallurgiſts have aſſerted; becauſe fraud might then perhaps become too common. It is only meant to indicate, that, as no gold is to be expected from marcaſites, where no native gold is found in the neighbourhood; in the ſame manner no marcaſites ought to be deſpiſed, which are found in tracks where gold ores are dug; but at the ſame time care muſt be taken not to be deluded by the mention of volatile gold, as it is a notion really contradictory and ſuſpicious, and then there can be no fear of being miſled.

I am not perfectly clear, whether the gold is really diſſolved and indurated, or, if I may ſo expreſs myſelf, vitrified in the Shirls (Schirlkornern), provided by this mineral body is meant a garnet ſubſtance (Sect. 68. of the Author). But I have ſeen a piece of what is called *Shirl*, whoſe texture was exactly like the Schemnitz blende; and, in this caſe, it might perhaps hold the ſame contents (Sect. 175. of the Author). For the other gold ores, I have not had an opportunity of ſeeing any from thoſe places where gold is ſearched for and really found. *The Author.*

[*b*] This Pyrite is of a bright yellow colour, cloſe and compact. The gold in this ore is ſaid to be *mineralized* by ſulphur, by means of iron, becauſe it cannot be extracted by *aqua regia*, or by amalgamation. *Kirwan.*

It

3. Mineraliſed by means of quickſilver, *Aurum ſulphure mineraliſatum mediante mercurio*, auriferous cinnabar. It is ſaid to be found in Hungary [*c*].

4. Mineralized

It is well known, that gold may be diſſolved by *liver of ſulphur*; the following is the proceſs given by Apligny (p. 156 of his *Treatiſe on Colours*).

Pound *four pounds* of vegetable alkali (ſalt of tartar), and as *many* of ſulphur, with *one* of leaves of gold; melt the mixture in a crucible with its cover; pour the fuſed matter on a marble; pound it again when cold, and put the whole in a matraſs, with hot water; which, being filtrated, is of a yellow greeniſh colour, containing the gold diſſolved. Now, as we know that *hepar ſulphuris* has been found in ſeveral pyrites, and Maſcagni aſſerts (p. 279. of his *Commentario*) to have found it in thoſe of the lagoons near Sienne, in Italy; is it not very natural to conclude, that this noble metal may be really mineralized in the auriferous pyrites? *The Editor.*

The Tranſylvanian gold pyrites, in which no gold can be diſcovered by the eye, hold from 50 and 100, to 110 ounces and upwards, in an hundred weight. Thoſe, where the gold appears in the pyrites, like ſtrewed Spaniſh ſnuff, hold 250 ounces, but they are very ſcarce. The mountain of *Faczebaya* near *Zalathna*, is remarkable for its gold pyrites; they ſeem likewiſe to contain ſemi-metallic parts. *Brunnich.*

[*c*] Mr. Sage, quoted by his two great admirers, Meſſieurs Romé del Iſle (p. 420. Vol. I. of his *Cryſtallogie*), and Dr. Demeſte (p. 466. of his *Letter* 44.), ſpeaks of a ſpecimen of gold from Hungary, now in the French King's cabinet at Paris, which is cryſtallized into quadrangular priſms, of a grey-yellowiſh colour, and of a brittle conſiſtency. This Mr. Sage aſſerts to be the reſult of a mercurial amalgam of native gold. *The Editor.*

They ſometimes find quickſilver in the chafts of the mines of *Michael* and *Siglisberg*, near *Shemnitz*; but the people have no idea of its containing gold, which may be the caſe, if it were well ſeparated. It is moſt probable that the other Hungarian cinnabars contain none; but I ſhall be able to

4. Mineraliſed by means of zinc and iron, or ſilver. *Aurum ſulphure mineraliſatum mediante zinco & ferro, aut argento.* The ſchemnitz blende [*d*].

At Schemnitz, in Hungary, are found zinc ores, which contain a great deal of ſilver, and this ſilver is very rich in gold. *See Sect.* 175. *of the Author.*

SECT.

ſpeak of this with more certainty, after I have made trials with them. *Brunnich.*

[*d*] Wallerius ſpeaks of two kinds of this ore; one, the *Pſeudogalena aurifera rubens*, found in *Schwarzeuberg* mine of Saxony; and the *Pſeudogalena aurifera nigreſcens*, which is reckoned amongſt the *ſilver ores*, the gold being in a very ſmall quantity, found at *Schemnitz*, in Hungary.

But Profeſſor Brunnich, in his notes to this Section, enumerates the following varieties of mineralized gold ores; *viz.*

5. Mineralized by means of a cubic lead-ore containing ſilver. From the mines of Michaeli, and ſome ſhafts in Tranſylvania.

6. Mineralized by means of a copper pyrites, with ſilver. Is called *gilf* in Hungary; has a compact pale yellow ſurface, and muſt not be confounded with gold pyrites.

7. Mineralized by means of red gilder-ore. The *Cremnitz-ores.*

8. Mineralized by means of antimony, in which it ſometimes appears. From the mountains of *Magarca* or *Margara*, near *Deutſchlipſh*, at the foot of the Carpathian mountains.

9. Mineralized by means of cubic lead-ore, iron, and unknown volatile parts. From Nagyai, near Deva, in Tranſylvania. Scopoli deſcribes this ore in his third *Annus Hiſtorico Naturalis*, as follows; Its colour is black; the richeſt pieces are lamellated almoſt like an iron-glimmer, with a degree of flexibility. The vein is quartz, which is ſometimes looſe, and wherein the ore is very minutely ſcattered.

10. Native gold, with *black-lead* (or *molybdæna*), has been broken near *Rimezembat* in *Upper Hungary*; but whether it has been mineralized with it, I have had no opportunity of examining.

In

SECT. 264. (Additional.)

Observations on Gold, and its mineralizations.

Gold is juſtly called the *King of Metals*, as it is the moſt ductile, maleable, heavy, and unalterable of all metals. When expoſed to air, immerſed in water, or buried in the earth, ſuffers neither decompoſition in its ſubſtance, nor ruſt, or even change of colour in its ſurface, although the duſt, or appoſition of external particles, may diſguiſe its luſtre; but, on being

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In all the above ſpecies, the gold is either intirely native; but ſo minutely divided, and ſo looſely ſcattered, that it can only be ſeen through microſcopes, and often cannot be ſeen at all, before it is ſeparated by various proceſſes; or it may not be in form of native gold, but as a gold as it were in embryo; in which caſe fire is neceſſary, in order to bring the conſtituents parts together, and to add thoſe that are wanting: in that caſe likewiſe it is never without ſilver. *Brunnich.*

To the above may be added the following ores;

11. Gold, with *arſenical pyrites*, is found alſo at *Saltzberg* in *Tyrol*, in mountains of quartz and ſhiſtus. It contains only 25 grains in the quintal; and, nevertheleſs, this mine affords a profit of 500 pounds *per annum.*

12. With a *white*, *red*, *or vitreous ſilver ore*, near Cremnitz, and Schemnitz, in Hungary.

13. With a *ſulphurated* ore of *ſilver*, *iron*, *lead*, and *manganeſe*, at Nagaya in Tranſylvania. Its ſpecific gravity is = 4,043. It is ſaid to afford 10 ounces per quintal.

14. With *ſulphurated iron*, *copper*, and manganeſe, at Nagaya. *The Editor*, from Kirwan, Mongez, Bomare, &c.

waſhed

waſhed off, it appears as bright as before; and when expoſed to the moſt violent fire, is quite fixt, without ſuffering calcination, nor ſenſible change or loſs in its maſs.

Meſſieurs Boyle and Kunkel kept gold conſtantly fuſed in a violent heat, during two months, and found not a ſingle grain to have been loſt. It is true, that when expoſed to the focus of a large burning lens, it is evaporated, but without changing its metalic ſtate. The late celebrated Profeſſor Macquer ſhewed me, at Paris, a plate of pure ſilver, which he had expoſed to that viſible atmoſphere, which ſurrounded the ſaid melted gold; and, by means of a magnifier, numberleſs particles of the gold could be very well diſcerned as attached to its ſurface. This accounts for the aſſertion of Mr. Lavoiſiere, in the *Memoires* of the *Academy of Sciences* at *Paris*, for 1782, who ſays, that gold, when expoſed to the flame of a lamp, blown by a current of dephlogiſticated air, (which is the moſt violent degree of heat that has ever been produced, and is one of the moſt important modern diſcoveries) is intirely volatilized, without leaving behind the leaſt mark of calcination.

However, Mr. Kirwan obſerves, that on expoſing gold to the focus of that moſt powerful lens, made by Mr. Parker, in London, for ſome hours continuance; although it loſt no ſenſible part of its weight, yet, when in contact with earthy matters, it communicated a blue or purple tinge to them; from whence it

appears that ſome minute, though inſenſible portion of it, was really dephlogiſticated.

If a ſolution of gold in *aqua regia* be properly mixed with that of tin diſſolved in the ſame menſtruum, a fine *purple powder* is precipitated, called by the name of *Caſſius*, its inventor, which produces the fineſt laſting purple colour. This powder, mixed with vitreous ſubſtances, is employed preferably to any other by encauſtic painters and glaſs-manufacturers. The late famous Chymiſt, Mr. Macquer, deſcribes, with great accuracy, in his Dictionary, various proceſſes to obtain, with certainty, this precious calx of gold.

If volatile alkali is added to the ſame ſolution of gold by *aqua regia*, a reddiſh yellow powder is precipitated, which is the *aurum fulminans*. It is alſo commonly made, by diſſolving gold in a kind of *aqua regia*, made with *nitrous acid* and *ſal ammoniac*, from which the *fulminating gold* is afterwards precipitated by the fixed alkali. A few grains of this powder detonate with a prodigious noiſe. When expoſed in a metallic ſpoon or plate, over a candle, coals, or a red hot iron; or when, by other means, it is ſufficiently heated, its fragor is 64 times greater than an equal quantity of gun-powder.

A degree of heat, as between the 120 and 300° (at which the nitrous and vitriolic acid boil) is ſufficient to produce this amazing exploſion, by which the moſt violent effects are produced. *Ten* or *twelve grains*, exploded on a metal-plate, perforate and lacerate it; and a few ounces, having

having exploded together, by incautiouſly drying it, have ſhattered the doors and windows of the apartment.

Even ſimple triture, or percuſſion alone, is enough to cauſe this powder to explode with all its violence, by which dreadful accidents have ſometimes happened. Macquer relates the caſe of a young man of his acquaintance, 22 years old, who ſhutting up a ſmall bottle of cryſtal, with about a dram of this powder, ſome little of it, between the ſtopple, was kindled by twining it: the bottle burſt into pieces, by which he was violently ſtruck, fell to the ground, and his eyes were quite ſhattered, ſo that he remained irrecoverably blind. And it is remarkable, that the greateſt part of the contents in the bottle did not detonate, a quantity of them being found unaltered and diſperſed in the room. Profeſſor Bergman has publiſhed a very elaborate diſſertation on this *fulminating powder*, in the ſecond vol. of his Opuſcula; but this wonderful phenomenon ſeems not yet compleatly accounted for in any hypotheſis as yet known, nor even in that propoſed by the celebrated Scheele, in his *Treatiſe on Fire*, Sect. 82. as he ſuppoſes there what ſeems not at all admiſſible; *viz.* that the *matter* of *heat* is a compound of *phlogiſton* and *dephlogiſticated air*. See Note [*f*] to page 347. of this *Mineralogy*.

It is on account of the ſingular and excellent natural qualities of this metal, which are conſiderably heightened by its ſcarcity, that gold

is ſo much valued among all the civilized nations of the world, as the Noble Author ſaid in Sect. 261. Mr. Paucton, in his *Metrologie*, p. 94. ſays, that one cubic foot (French meaſure) of gold, is worth 2153000 *livres tournoiſes*, or 89708 *guineas* and 7 *ſhillings*, ſuppoſing the *louis d'or* equal to the *guinea*; and that the reſpective value of the ſame *cubic foot* of gold, is equal to 25,6 cubic feet of ſilver, each of this laſt metal being reckoned worth about 84080 *French livres*, or 3503 *guineas* and 8 *ſhillings*; ſo that if we ſuppoſe the monied ſpecies in *France* to be but two *milliards* of *French livres*, according to the eſtimation of Mr. Necker, in his treatiſe upon the *Commerce of Corn*, the whole amount ſhould make but a ſolid cube of gold, leſs than *ten feet* on each ſide. So trifling is the phyſical object that excites the activity of 22 millions of the human ſpecies, the number that is ſaid to be that of the inhabitants of France!

As to the natural exiſtence of gold in the bowels of the earth, there have been two oppoſite opinions among Mineralogiſts; ſome pretending, that it is only found in its *metallic* or *native form*; and others, that it is ſometimes found *mineralized*, in an intimate union with other mineral ſubſtances. The famous Profeſſor Bergman was among thoſe of this laſt opinion; but Mr. Kirwan holds the firſt, and ſays, that although Mr. Bergman inclines to the opinion of the mineralization, yet he is candid enough to own, that the gold, when extracted from this

ore,

ore, is of a granular, or angular form. It is therefore, says Mr. Kirwan, very doubtful whether it was not rather *mixed*, than truly *combined*, with the sulphur and iron: and its proportion being exceedingly small, so that one hundred pounds of the pyrites contain hardly one ounce of gold; it is not a wonder, that it should escape the action of *aqua regia*; more especially, as the nitrous acid becomes so phlogisticated, by acting on the pyrites, as not to be able to dephlogisticate the marine. Likewise Mercury, by the circumstantial accident of the gold particles being enveloped, or surrounded by the sulphureous iron, can have no access to it.

These arguments against true mineralization of gold, are fully answered by those facts, and reasonings, expressed by the Noble Author in the preceeding Sect. 263, and in its notes. Besides, it is well known, that gold can be combined and calcined *via sica*, by the *liver of sulphur*, and some semi-metals, as has been said in the same Notes. This being acknowledged on both sides of the question, why should we insist in denying this mineralization, when it is out of doubt, among all Mineralogists of rank, that volcanic fires have had a great share in the convulsions and revolutions of this globe, of which every one has the most convincing proofs almost every where? The account given by Mr. Hacquet [*a*], of

[*a*] By this account of Mr. Hacquet, it appears that gold is found mineralized; *viz.*

1. By *sulphur*, zinc, and arsenic, in a grey-yellowish volca-

of the gold mines at Nagy-Ag, in Tranſylvania, the ancient Dacia, which lies about 45 *degrees* of latitude, offers the moſt convincing proofs of this aſſertion. The country all round theſe mines, bears an inconteſtable appearance of being a volcanic one; and among various other metals, there are found at leaſt 13 kinds of gold-ores, moſt of them mineralized. *The Editor.*

SECT.

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nic ore, which is called *Cottoners* (or Cotton-ore), on account of its lightneſs and texture.

2. By iron and arſenic, formed by ſtrata, one containing black ſilver ore, then ſpatum, galena, quartz, and grey gold ore: it gives about half an ounce *per cent.*

3. By ſulphur, antimony, zinc, ſome arſenic, and ſometimes iron; this is a grey gold-ore mixed with quartz.

4. In form of crooked threads, mixed with quartz and gypſeous ſpath: it is a poor mine.

5. Dendritiforme, like the mocho-ſtone, or the agate from Aberſtein, in the Palatinate, but theſe black dendrites are in a reddiſh ſtone,

6. A morphous very compact in ſmall grains, with ſpath and quartz: it gives two ounces of gold, and more of ſilver, *per* quintal.

7. By ſulphur, great part of zinc, and little of antimony and arſenic: not a rich ore of gold.

8. Of a black, or dark reddiſh colour, containing an auriferous pyrites, not rich.

9. Of a blueiſh colour, mineraliſed by ſulphur, antimony, iron, and a little arſenic, mixed with ſilver; very rich in gold.

10. Partly laminated with needles of a blackiſh yellow colour; this gives 66 oz. *per* ℔ of gold according to Scopoli.

11. Foliated with gypſeous ſpath, and yellow pyrites.

12. In irregular lamina, on a greyiſh argille. The gold looks like ſilver, and is ſurrounded by ſpars of a pale roſy colour.

13. In

SECT. 265. (167.)

2. Silver, *Argentum, Luna.* This Metal is

1. Of a white ſhining colour [*a*].

13. In cryſtallized lamina, from 2 to 4 lines diameter, of an hexangular form; it is very much like the *molybdene.* Profeſſor Brunnich, on this account, calls this ore, but improperly, *minera auri martialis pictoria.* The vein has been loſt a long while; but a new branch was lately met with, on mining for letting out the water from the main. This ore is very rare, and has given 372 ounces, *per* ℔ of noble metal, 5 parts of which were gold, and one ſilver. *The Editor from Journal* du Phyſique, *for January* 1785.

[*a*] Silver, called *Luna* or *Diana*, by the alchemiſts, is a perfect metal, the whiteſt and of the moſt vivid brilliancy among them all.

Its ſurface, however, *tarniſhes*, and becomes of a *dark brown* colour, when expoſed to *hepatic*, or phlogiſtic efluvia (N° 10.). If rubbed on a paper, or on a chalky white ſurface, it leaves *blueiſh* marks. Its calx being precipitated by volatile alkali, gives a *yellow* tinge to glaſs (*See* Gellert's *Metal. Chym.* p. 301.): and I have ſeen ſome ſtained with it of ſo high a colour, as to appear quite *red.* Mr. Macquer, by expoſing the ſame ſilver, 20 times, to a very violent fire, found ſome little vitreous calcinations of an *olive* colour. And by melting ſilver with *gold*, or *ſteel*, in a due proportion, it aſſumes a *greeniſh*, or a *blueiſh* colour; ſo that this noble metal is capable of producing the *white*, *yellow*, *red*, *green*, *blue*, and *olive* colour, more or leſs conſpicuouſly, according to the various circumſtances of heat, and proportions of the mixture.

Fourcroy ſays, that ſilver has neither *ſmell* nor *taſte*, when pure. But its diluted ſolution has a particular diſagreeable taſte, very different from that of other metals.

Silver is ſo fixt by itſelf in the fire, that, after being kept a whole month in fuſion, it had only loſt one 60th part of its weight, which might be on account of ſome alloy. It is therefore incapable of being calcined by mere heat; and the calx of ſilver, which can only be made by means of its ſolu-

2. Its ſpecific gravity to water is as 11,091 1000 [*b*].
3. It is very tough or ductile, ſo that a grain of it may be ſtretched out to three Swediſh ells, of 2 feet each, (or 5 *feet* 8 *inches* Engliſh meaſure), and two inches in breadth.
4. It is unalterable in air, water, and fire.
5. It diſſolves in the acid of nitre, and alſo by boiling in the acid of vitriol [*c*].

6. If

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tion in acids, is reducible to its metallic form, without the addition of any phlogiſtic ſubſtance.

But when ſilver is expoſed to the violent heat of the ſolar rays, collected by a powerful burning lens, a kind of ſmoke is ſeen ſurrounding it, which proves at laſt to be the minute particles of the metal raiſed and diſperſed by heat; as is evident, if a thin plate of gold is expoſed to it, on which ſurface they may be ſeen with a magnifier. This is the ſame phenomenon which was obſerved on gold, when in ſimilar circumſtances. *See page* 529.

If it is ſlowly cooled, after having been fuſed, it cryſtallizes into octoedral figures, though ſeldom perfectly ſo; for the moſt part it only ſhews the half of them, appearing like ſo many quadrilateral pyramids. *Editor chiefly from* Wallerius, Fourcroy, Bomare, Mongez, &c.

[*b*] Its ſpecific gravity, according to Bergman, is = 10,552; but, according to Kirwan, it is = 11,095. *See the Note* [*b*], to Sect. 295. *On the cauſes of variation of the ſpecific gravities of bodies.*

A cubic French foot of Silver weighs 720 pounds of *French weight*, according to Macquer. As to its relative value, ſee p. 532.

Silver is harder and more elaſtic than *lead*, *tin*, or *gold*; but is ſofter than *iron*, *platina*, or *copper*. It ſtiffens under the hammer, but becomes ſoft by nealing: and is the moſt ſonorous of all pure metals, except copper.

A ſilver wire, a tenth of an inch thick, may ſupport, without breaking, 270 pounds weight, according to Macquer, Fourcroy, and Bomare; but Wallerius carries it farther, unleſs there be ſome typographical error, ſaying, it may hold 370 pounds,

6. If precipitated out of the acid of nitre with the common ſalt, or with its acid, it unites ſo ſtrongly with this laſt acid, that it does not part from it, even in the fire

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370 pounds; and aſſerts, that a veſſel may be made ſo thin of this metal, without being heavier than a ſingle *grain*, which will hold a cubic inch of water.

[*c*] Silver requires nearly twice its weight of nitrous acid to be diſſolved; this is it's moſt ſpecific menſtruum; even cold, it attacks ſilver with a conſiderable efferveſcence, grows hot, and emits a large quantity of vapours of an orange colour, which diminiſh in proportion as the ſaturation advances.

The metal looks of a pale brown colour in the conflict; and the ſolution becomes quite black; but I have obſerved, that this laſt appearance was owing to a thin black fuliginous ſubſtance, like ſmut, which was at once formed into a cruſt on the ſurface of the thin plates of ſilver, in the firſt attack of the acid upon them. This black ſubſtance is a very ſingular phenomenon, which I know not how to account for. Theſe black cruſts being comminuted into ſmaller and ſmaller particles, by the inteſtine motion of the efferveſcing acid, produced the black appearance of the whole; and, when it was over, they were very diſtinctly ſeen to fall to the botom of the veſſel, and to form a black ſediment, leaving the liquid ſolution quite tranſparent, but of a blue colour inclining to green, which laſt might be attributed to ſome ſmall mixture of copper, altho' the ſilver was of the pure kind, myſelf having bought it as ſuch, from one of our beſt refiners, at *Foſter lane* in *London*.

The Chemiſts of Dijon only ſay, that the nitrous ſolution of ſilver looks of a fine blue colour, if the acid is pure and well concentrated; but if it has any mixture of vitriolic or marine, a precipitate of *vitriolated ſilver*, or of *luna cornea*, takes place. Afterwards the ſolution becomes as colourleſs as water; but gives a laſting black-purple tinge to animal ſubſtances.

This ſolution is of great uſe in chemiſtry; and, in particular it ſerves to purify the *nitrous acid*, or *aqua-fortis*, from

fire itſelf, but melts with it into a maſs like glaſs, which is called *luna cornea* [*d*].

7. It

from the mixture of the *vitriolic* and *marine acid*, which are often mixed therewith; as, by pouring in it little by little a few drops of it, theſe two acids are precipitated, and the nitrous afterwards is decanted in a pure ſtate. The ſame ſolution, diluted in diſtilled water, is a very nice teſt to diſcover any vitriolic, or marine part, contained in Mineral Waters.

The nitrous ſolution of ſilver, when properly evaporated, produces a large quantity of white cryſtals, of a ſcaly form; ſome are hexagonal, and ſome of an octoedral figure, which are called *Lunar Cryſtals*. This ſalt is fuſible in a moderate fire; loſes its water of cryſtallization; becomes black, and is very corroſive; on account of which quality it is caſt into ſmall cylindrical moulds, and is known under the name of *Lapis Infernalis*, as its uſe is to corrode the ſpongious fleſh of ſores, &c. According to Mr. Scheele, the dark colour of this cauſtic ſubſtance proceeds from the alloy of copper, for even the refined ſilver, by the common method, contains ſome of this metal. *See at the end of the following note* [*d*], *the beſt method of purifying* ſilver.

The nitrous ſolution of ſilver may be decompoſed by *earthy*, *ſaline*, and *metallic ſubſtances*; and, when the decompoſition is made by *mercury*, a very curious precipitate takes place, which, by its ſimilarity to vegetables, is called *Arbor Dianæ*.

Aqua regia diſſolves very well this metal, but it is immediately precipitated, forming a *luna cornea* with the muriatic part of this ſolvent. *The Editor, chiefly from the* Elements of Chemiſtry of Dijon, and Fourcroy.

[*d*] The marine acid attracts the calx of ſilver, but cannot remove its phlogiſton; and therefore cannot diſſolve it in its metallic ſtate. *Bergman.*

However the marine acid, if well concentrated, or rather reduced into an aerial form, diſſolves ſilver in its metallic ſtate. *Fabroni.*

Mr. Scheele, and after him Mr. Bertholet, aſſert poſitively, that the marine acid, being dephlogiſticated by its diſtillation over maganete, in the form of a yellow air or gas, diſſolves

7. It does not unite with the ſemi-metal *nickel*, during the fuſion.
8. It amalgamates eaſily with quickſilver.
9. It is, in the *dry way*, diſſolved by the *liver of ſulphur*.
10. It has a ſtrong attraction to ſulphur, ſo as readily to take a reddiſh-yellow or black colour, when it is expoſed to ſulphureous vapours.
11. It has no attraction to arſenic; whence when the red arſenical ſilver ore, or *Rothgulden Ertz* of the Germans, is put into the fire, the arſenic flies off, and leaves the ſulphur (which in this compound was

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diſſolves all the metals, without excepting *gold*, *ſilver*, nor *mercury*. See *Scheele's Eſſay* 5, §. 25 *H*.

The vitriolic acid, being diſtilled alſo over the manganeſe, diſſolves *ſilver*, *gold*, and *mercury*, as Dr. Crell aſſerts. *See Note* [*e*] *to page* 517.

Silver is precipitated from the *vitriolic* and *nitrous acids* by the *marine*; and from the *nitrous*, in great meaſure, by the vitriolic. *Kirwan*.

The ſilver extracted from *luna cornea*, is purer than can be made by cupelation, and is the only one to be truſted to in the niceſt operations of chemiſtry. But the proceſs, to free it from the *muriatic acid*, is very tedious, and preſents a very unexpected phenomenon, as this metal, though one of the moſt fixed kind, is nevertheleſs ſo volatiliſed thereby, that it eſcapes through the pores of the crucible; and ſmall globules of ſilver are found afterwards in the cover, and even in the ſupport of the crucible. According to Cramer, this loſs may be prevented by ſmearing the crucible with *black ſoap*, and mixing to the *luna cornea* half its weight of oil or tallow, which laſt muſt alſo be added, little by little, during the operation. *See* Elem. de Chimie, de Dijon, Vol. II. p. 221.

the

the *medium uniens*) behind, united with the Silver in form of the glaſs-ſilver-ore, or *glaſs ertz*.

12. It is not diſſolved by the glaſs of lead; and conſequently it remains on the cuppel.

13. It is exhaled, or carried off by *volatile metals* and *acids*, as by the vapours of *antimony*, *zink*, and the *acid of common ſalt*.

14. It melts more eaſily than copper [*e*].

SECT. 266. (168.)

Native Silver.

Silver is found,

A. Native or pure, *Argentum purum nativum*. Native ſilver moſt generally is nearly of ſixteen carats ſtandard [*a*]. It is found

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[*e*] This was a general opinion, *viz.* that ſilver required a leſs degree of heat than copper to be melted in the fire, as the noble author aſſerts; but the contrary appears, by the nice thermometer lately invented by Mr. Wedgewood, as may be ſeen by the note to page 230. This new inſtrument is one of the moſt valuable acquiſitions of modern date, for all kinds of proceſſes, and philoſophical diſquiſitions in metallurgical, chemical, and various other operations of art by fire; all which were till now regulated only by gueſs, without any fixed ſtandard to aſcertain the real degree of heat belonging to each. *The Editor.*

[*a*] In the firſt edition of this Mineralogy, corrected by the late Dr. Lewis, uſe is made of the word *loths* inſtead of *carats*; and it is added, that native ſilver never is fully of 16 *loths*; which laſt is called the *Fine Mine* of *Silver*. By this it ſeems to be meant, that *native ſilver* is found nearly free, but never fully ſo, from *all baſe metals*, *as copper*, *lead*, &c. *The Editor.*

1. Thin

1. Thin ſuperficial, plated or leaved.
2. It is alſo found in form,
   a. of ſnaggs, and coarſe fibres.
   b. Of fine fibres. Capillary ſilver.
   c. Arboreſcent. From Potoſi in America, and Kongſberg in Norway [*b*].
   d. Criſtaline or figured. This is very ſcarce to be met with: it has diſtinct figures, with ſhining ſurfaces; it is, however, ſometimes found at Kongſberg [*c*].

The ſilver from America is ſaid to be found for the moſt part native; ſo it is likewiſe at Kongſberg in Norway [*d*].

It

[*b*] Sometimes ſilver is found, the ſurface of which reſembles coarſe linen, or what is called *knit cobalt* in Saxony; it is ſo found abundantly in Potoſi, rarely at Saxony, and at Kongſberg; perhaps our author has reckoned theſe figures among the *dendritical forms*. Brun.

[*c*] There appears likewiſe a kind of cryſtallization on the thin plates of *native ſilver*, their ſurface being full of minute pyramidal cryſtals, in the ſame manner as the thin plates of gold which have been mentioned before. *Brun.*

[*d*] A good deal of it likewiſe breaks in Saxony among other rich ores. *Brunnich.*

Wallerius diſtinguiſhes the *native ſilver* into the following ſpecies; *viz.*

1. In *irregular maſſes* and *lumps*, found at *Kunſberg* in *Norway*, and at *Neumarken* in *Wermeland*, where it was in a bed of clay.
2. *Granular*, and in a jagged form, at *Potoſi* and *Mexico*, in Spaniſh America; and at *Kunſberg*.
3. *Dendritiform* and *arboreſcent*, in the ſame places, and at *Schneeberg*.
4. *In thin leaves* between the fiſſures of ſtones, as at *Kunſberg*, *Freiberg*, *Johangeorgenſtadt*.

5. *In*

It is not commonly ſo in other European mines. In Sweden it is found native in a very ſmall quantity, in the mines of Salberg in Weſtmanland, of Lofaſen in Dalarne, of Hevaſſwik and Sladkierr in the province of Dal, of Sunnerſkog, in the Province of Smoland, and in the iſland Utoen in the Lake Malaren.

It was once found in pretty large lumps in a vein of clay, in one of the iron mines at Normark, in the province of Wermeland. It was there mixed with nickel, which was partly decayed or withered; and under this circumſtance it formed the compound ore called the *Stercus Anſerinum* or gooſe-dung ore (See ſect. 282.) At this place the argillaceous vein croſſes the veins of the iron ore, and will perhaps be found to have more of theſe riches, even in ſeveral other places, if well ſearched, as is done in other countries, oftentimes not on ſuch evident marks or ſigns [*e*].

SECT.

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5. *In a capillary form*, at *Schemnitz*, in Hungary; at *Freiberg*, and at *Maricnberg*, in Saxony. Of this kind is the *Cobweb ſilver* ore of the Spaniards.

6. In a cryſtallized form, at *Kunſberg*, and at *Sainte Maria* in Alſatia.

7. *Superficial*, at *Salberg*, and *Læfœſen*.

Mr. Daubenton reckons eight varieties of *native white ſilver*, ariſing from their peculiar forms: but he reckons ſeparately ſome of the above forms. *The Editor.*

[*e*] The Mineralogical Academy at Freyberg, has ſome *native ſilver* in *coal*; this is ſhewn there among the Konſberg pieces. *Brunnich.*

And Lehman, quoted by le Camus (Journ. de Phyſique, for March 1779, p. 183), ſpeaks alſo of a ſimilar *ſilver ore*, found in a mine of peat-coal. *The Editor.*

SECT. 267. (additional).

Native Silver, mixed, *or* alloyed, *with other metals.*

Native ſilver is ſeldom found pure, *viz.* by itſelf alone. The following are the known inſtances of theſe alloys:

1. Native ſilver, united to gold, *Bergman's* Sciagraphia §. 154. That which is found

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Native ſilver is found in various forms, as already mentioned, inhering either in *baro-ſelenite*, *lime-ſtone*, *ſelenite*, *quartz*, *chert*, *flint*, *ſerpentine*, *gneis*, *agate*, *mica*, *calcareous ſpar*, *pyrites*, *ſhiſtus*, *clay*, &c.

Alſo in ſeparate maſſes of various ſizes (ſome of the weight of 60 pounds) in or near the veins of moſt metallic ſubſtances, particularly in *Peru*, and frequently in various parts of Europe; either of a *white*, *brown*, or *yellowiſh* colour.

Sometimes it is diffuſed through *ſand* and *ochre*; and alſo in grey *lime-ſtone* in the Lower Auſtria; and in a *greeniſh clay* near Schemnitz; or mixed with *ochre*, *clay*, and *calciform nickel*.

It is ſeldom found *pure*, being generally alloyed with *copper*, and ſometimes with a ſmall proportion of *gold*, *iron*, or *regulus* of *antimony*; and ſometimes with about 5 *per cent.* of *arſenic*.

According to Henckel and other Mineralogiſts, ſilver, in the capillary form, and in thin ſcales, is produced by the decompoſition of the *red ſilver mine*: and Wallerius aſſerts, that if ſulphur is mixed in a ſmall heat with ſilver, this laſt takes a capillary form.

At *Kungsberg*, and at *Sainte-Marie-aux-mines*, in Alſace, ſilver is found in the form of ſolitary cubes; and octoedral lumps, of 50 and 60 pounds weight, have alſo been found in the laſt of theſe two places. *Mongez.*

of

of this ſpecies near *Konigſberg*, contains ſo much gold, as to acquire a yellow colour from it. *Kirwan.*

2. Mixed with copper. *Berg.* Sc. § 155.
3. United to gold and copper. *Berg.* Sc. § 156.
4. Amalgamated with mercury, found in the mines of Salberg; as J. R. Foſter notes to *Brunnick* [*a*].
5. United to iron. *Berg.* Sc. § 157. The iron in this ore ſeldom exceeds 2 *per cent*: but oftner it hardly amounts to $\frac{1}{100}$. *Mongez.*
5. United to lead, ſometimes in ſuch quantities, as to be worth the expences attending the ſeparation [*b*].

6. United

[*a*] Mr. Romé de l'Iſle, ſpeaks of a native amalgam of ſilver and mercury, now in the French king's cabinet at Paris, which was found (at *Muſchel Landsberg*, in the Dutchy of *Deux-Ponts*) in a ferrugineous matrix, mixed with cinnabar. This ſpecimen is of a cryſtalline hexagonal form, and of a large ſize. See his *Cryſtallogie*, Vol. I. p. 420. See alſo the Sect. 287. of this Mineralogy. *The Editor.*

[*b*] Silver is always contained in lead, though it is generally in ſo ſmall a quantity, that it is not worth the charges of ſeparating it. Thus, accurate Aſſayers never fail of trying the lead they uſe in their coppellations, in order to account for the reſpective addition ariſing from it to the neat produce of metal that remains in the coppel. In the reign of Edward the Firſt of England, near 1600 pounds weight of ſilver were obtained, in the courſe of three years, from a mine in *Devonſhire*, which had been diſcovered towards the beginning of his reign, *viz.* about the year 900. The lead mines in *Cardiganſhire* have, at different periods, afforded great quantities of ſilver. Sir Hugh Middleton is ſaid to have cleared from

7. United to arſenic. Mr. Monnet found this ore among thoſe from Guadanal canal in Spain, as may be ſeen in the ſupplement to the *Journal de phyſique*, for 1778, page 50. The mine of *Samſon*, near *Andreaberg* in the *Hartz*, furniſhes this ſpecies of ſilver. Mr. Mongez remarks, very properly, that theſe ores muſt be diſtinguiſhed from thoſe in which the arſenic is in the form of an acid; for in this caſe, they are properly mineralized by it; and ſuch ſeem to be thoſe of Sect. 170. 235. and 248. of the Author. (See Sect. 275.) Whilſt there muſt be only a mixture with the na- *native ſilver*, or with it's calces, if the *arſenic* be in it's *reguline form.*

8. Native ſilver united to antimony. *Berg.* Sc. § 159. This ore being roaſted, gives out ſome ſmoke, but has not the ſmell, ſimilar to that of garlic, which arſenic gives out when burned.

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from them 2000 pounds in a month. The ſame mines yielded, about the year of the Rebellion (1745) *eighty ounces* of ſilver out of every *ton* of lead. The lead ores from *Brunghill* and *Skekorn* produced alſo a conſiderable quantity of Silver. The lead only in one of the ſmelting houſes at *Holywell* in Flintſhire, produced no leſs than 37521 ounces, or 3126 ¾ pounds of ſilver, from the year 1754 to 1776; and from 1774 to 1776. There are ſome lead-ores in Great Britain, which, though very poor in lead, contain between 3 and 400 ounces of ſilver in a ton of lead; but it is not to be expected that the Proprietors ſhould be forward in declaring it to the world. It is commonly obſerved, that the pooreſt lead-ores yield the moſt ſilver; ſo that a large quantity of ſilver is probably thrown away in England, from not having the pooreſt ſort of lead-ores properly aſſayed. *The Editor, from* Watſon's Eſſays, *Vol. the Third.*

9. Joined to the regulus of arſenic and iron. *Berg.* § 160. This ore is found in the mines near *Freiberg*, where it is called *White-ſilver ore.* Mongez.

The above three metallic ingredients are nearly in equal proportions.

All the ſpecies mentioned in this Section have metallic properties and appearances: the contaminating matters are ſometimes extremely ſmall; but not to be neglected, when they exceed $\frac{1}{300}$ part of the whole maſs. *Bergman*, ibid.

10. Native ſilver mixed with the alkaline limé-ſtone from Annaberg, deſcribed by Mr. Juſti, *Brunnich* [*c*].

11. Sandy ſilver ore, without any metallic ſhining.

11. Silver

[*c*] Wallerius has formed a particular claſs of ſtony ſilver ores, which he diſtinguiſhes by the epithet *Lapidea*, and is the 397 ſpecies of his *Mineralogical Syſtem*: under this head he deſcribes the following varieties;

1. The *calcareous* ſilver ore (*argentum alkali mineraliſatum*, which ſeems rather an ambiguous denomination) found at *Annaberg* in Auſtria.
2. The *ſpathoſe*, or *ſparry* ſilver ore, which is either *white*, *variegated*, or *yellowiſh*, found at *Schemitz* in Hungary.
3. The *quartzous white* ore, in a powdery form, mixed with ferrugineous Scoria, found in *Potoſi*.

4 and 5. The *dark*, and the *variegated quartzous* ſilver ores.

According to this Author's deſcription, all theſe ores contain *native ſilver*, without any material difference, beſides the accidental colour, or the mixture of other earths.

It was alſo for the ſake of increaſing, as it ſeems, the number of theſe uſeleſs ſubdiviſions, that this celebrated Mineralogiſt formed his *Species* 398, containing the *dark-brown*, and the *yellow* ſandy ſilver ores; his Species 399 of the *foliaceous*

12. Silver ore in a red-brown ſhiſtus, deſcribed by Lehman; it is compoſed of argillaceous earth, micaceous hematites, ſulphur, calcerous ſpar, fluor mineralis, lead and ſilver. It contains about 7 or 8 ounces of ſilver on the hundred weight.

13. Soft ſilver ore. It is found among the marles and argillaceous earths, and is of various colours, either ſingly or mixed. It is ſomewhat ſimillar to the *gooſe dung ſilver ore*: and is found at Marienberg, Schemnitz, Huelgoet, in Brittany, &c. *Mongez.*

SECT. 268. (169.)

B. Diſſolved and mineraliſed, *Argentum mineraliſatum.*

With ſulphur alone, *Argentum ſulphure mineraliſatum.* Glaſs, or vitreous ſilver ore, *Minera argenti vitrea.*

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native ſilver ore; his Species 401, containing the following ſoft ſilver ores; *viz.* 1. The *ochreous* (or *margaceous*), variegated with *red*, *green*, and *yellow* ſpots, which is properly the ore that will be deſcribed in Section 282; 2. The *yellow*: 3. The *clayiſh*, unctuous to the touch: 4 and 5. The *ſolid* and the *porous* margaceous white ore: 6. The *argillaceous*; and, finally, the *copperiſh* ore, of a *green*, or *blue* colour; and his laſt article of *Minera argenti figurata*, found in ſome ſlates, which he had already deſcribed among the *copper ores*. The Editor.

This is ductile and of the ſame colour as lead; but, however, becomes black very quickly in the air [a]. It has, therefore,

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[a] This kind of ore is found either in large lumps, or inhering in *quartz*, *gypſum*, *gneiſs*, *pyrites*, &c.

It is of a *lamellar*, *granular*, or *capillary* form, or *cryſtallized*.

Though generally of a *lead colour*, ſometimes it is *grey* or *black*, even when firſt broken.

It's lamina are not only ductile, but even flexible, and malleable to a certain degree; and ſo ſoft, that they may be cut with a knife.

Its ſpecific gravity is = 7,2000.

100 parts of it contain from 72 to 77 of ſilver; and is rarely contaminated with other metal, except ſome ſmall portion of iron.

It is found in *Hungary* near *Shemnitz*, and in *Saxony* near *Freiberg*, particularly in the famous mine of *Himmelsfurſt*. Kirwan.

This ore ſeems to be nothing elſe but native ſilver, penetrated by *ſulphur*; for on being expoſed to a ſlow heat, this laſt flies off, and the native Silver remains in filaments. There are nine varieties of this ore;

1. Like *black-lead*, or *plumbago*, this is the moſt common of all.

2. *Brown*. Bruckman mentions one of this appearance, which was green in the inſide.

3. *Yellow*. This colour is owing to ſome arſenic contained in it, which forms an orpiment with the ſulphur.

4. *Greeniſh*.

5. *Blueiſh*. This is friable, like ſcoria of metals, and is called at Fryberg *Schlarckenerz*, ore of Scoria,

6. in form of *vegetations*.

7. *Lamellated*.

8. *Cryſtallized* into octaedral, or hexaedral priſms, and into decaedral pyramids.

9. *Superficial*; viz. covering the ſtones, or maſſes of other ores. *Mongez*.

But Wallerius, by ſubdividing ſome of theſe varieties, has added *two* more to this number. *The Editor*.

undeſervedly

undeſervedly got the name of *Glaſs-ore*; for that name rather belongs to the *minera argenti cornea*, or *horn-ſilver ore*, if indeed any ſilver-ore can be conſidered as *glaſſy*.

It is found in the ſame manner as *native gold*, viz.

1. In cruſts, plates, or leaves.
2. In the form of
   a. Snaggs, and of
   b. Criſtalline figures.

It is generally either of a lamellar or a grained texture, and is found in Kongſberg and in the Saxon mines, [*b*].

The *glaſs-ſilver ore* is the richeſt of all ſilver-ores; ſince the ſulphur, which is united with the ſilver in this ore, makes out but a very ſmall quantity of its weight [*c*].

[*b*] The Hungarian *glaſs ſilver-ores* are now ſcarce; ſome are now and then found in the wind-ſhafts, which are very frequently covered with a thin membrane, or rather cruſt, of the colour of pyrites. *Brun.*

[*c*] It contains about 180 marks of ſilver in the hundred weight. The medium between the *glaſs ore* and the *red gilder-ore*, is called *Roſch-Gewœchs* in Hungary, and *brittle glaſs-ore* in Saxony. It is of a black colour, and, when pounded, gives a black powder. In the mines of *Himmelsfurſte* near Freiberg, it is ſaid to have held 140 marks, but theſe pieces are very ſcarce at preſent. It ſometimes ſhoots into dendritical figures, between the cubic lead-ore, at a mine called The *Old Green Branch* near Freiberg. *Brunnich.*

SECT. 269. (Additional.)

Arſenico-martial ſilver ore, *Weill-ertz* in Germ.

This ore contains *ſilver* and *iron* mineralized by *arſenic*: this laſt is in a larger proportion than the *iron*. This is the *Pyrites argenteus* of Henckel.

1. It is a hard ſubſtance, of a white ſhining appearance, and of a compact, lamellar, or fibrous texture.

The brighteſt has leſs ſilver, this only gives 6 or 8 ounces per quintal: and the richeſt gives about *ten* per centum. It contains no ſulphur.

It is found in *Saxony*, the *Hartz*, at *Guadanal-canal*, &c. *Kirwan*, *Spec.* 7.

2. Of a yellowiſh-white colour, and of a ſtriated ſtructure, reſembling *biſmuth*, but much harder.

It melts very eaſily; and, if kept in fuſion, it loſes it's arſenic, and the ſilver remains almoſt intirely pure, as it contains but very little iron.

It produces about 60 *per cent.* of ſilver.

It is found near *Guadanal-canal* in Spain. *Kirwan*, *Spec.* 3.

3. Near the ſame place is found alſo another ore of the ſame kind; but the quantity of the arſenic in it is ſo great, that it would

ſcarcely

ſcarcely deſerve to be called a *ſilver ore*, if the arſenic were not eaſily diſſipated.

It is very ſoft, and eaſily cut; and, when cut, has a brilliant metallic appearance. It conſiſts of conchoidal laminæ.

The quintal contains only from 4 to 6 ounces of ſilver; but

It is eaſily reduced by evaporating the *arſenic* by fire, which then leaves the *ſilver* ſlightly contaminated with *iron*. Kirwan, ſpec. 4.

SECT. 270. (170.)

Red or Ruby ſilver ore. Rothgulden *in Germ.*

2. With ſulphur and arſenic, *Argentum ſulphure et arſenico mineraliſatum. Minera argenti rubra*, The red or ruby-like ſilver ore. The *Rothgulden* of the Germans [*a*].

The

[*a*] This is a heavy, ſhining ſubſtance, either tranſparent or opake; moſtly of a *crimſon* or *reddiſh* colour, though ſometimes it is *grey* or *blackiſh*.

It is found either in ſhapeleſs maſſes; or cryſtallized, in pyramids or polygons; or dendritical, or plated, or with radiated incruſtations.

Its matrixes are either the quartz, flint, ſpar, pyrites, ſparry iron-ore, lead-ore, cobalt ore, jaſper, baro-ſelenite, gneiſs, &c.

When radiated, or ſtriated, it is called *Rothgulden bluth.*

It not only cracks in the fire, but detonates with nitre.

Its ſpecific gravity is from 5,400 to 5,684.

The colour of this ore varies as the proportion of each of theſe ingredients varies in the mixture; viz. from dark grey to deep red; but when it is rubbed or pounded, it always gives a red colour. When put in the fire, it crackles and breaks; and when the crackling ceaſes, it melts eaſily, the arſenic at the ſame time exhaling in ſmoke. [*b*].

a. Grey arſenical ſilver ore; which is either,

1. Plated, cruſted, or leaved, and,
2. Solid.

b. The red arſenical ſilver ore,

1. Plated, cruſted, or leaved.
2. Solid or ſcaly, and
3. Cryſtalliſed [*c*].

In

According to Bergman, it contains in the *hundred*, 60, and ſometimes 70 of ſilver, 27 of arſenic, and 13 of ſulphur.

The darkeſt coloured ores of this kind are the richeſt; and theſe often contain ſome little iron. The yelloweſt are the pooreſt.

But the moſt yellow do not belong to this ſpecies, being, in fact, an *orpigment*, containing 6 or 7 per cent. of ſilver. *Kirwan*, Sp. 5.

This laſt kind is called *Roſi-cler* by the Spaniards. It comes chiefly from *Potoſi* in America. *Mongez*.

[*b*] Red gilder-ore, if very well pounded, or ground, turns of a *dark colour*: cinnabar, under the ſame circumſtances, becomes of a *bright red*: and orpiment grows *yellow*. But their cryſtalline appearance can eaſily be miſtaken. *J. R. Foſter*.

[*c*] Wallerius mentions the ſix following varieties of this notable ore, in his Species 388; *viz*. 1. The *red opake*, like cinnabar from Andreasberg in the Hartz, and from Salberg in Weſtmannia: 2. The *blueiſh* from Freiberg and Annaberg: 3. The *grey* from Freiberg and Andreasberg: 4. The *red tranſ-*

parent

In this laſt form it ſhews the moſt beautiful red colour, and is often ſemi-tranſparent. It contains about ſixty per cent of ſilver; and is found in the greateſt quantity at Andreaſberg in the Hartz [*d*].

SECT. 271. (part of Sect. 171.)

Mineralized by ſulphur, *little* arſenic, *and* iron. *Schwartz ertz, Schwartz gulden, Silber mulm.* in Germ.

It is a friable, withered, decayed ore.

a. Of a *black* or ſooty colour, and is therefore called by the Germans *Silberſchwartz*, or Ruſſigtes-ertz [*a*].

SECT.

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parent amorphous, of the garnet colour, from *Potoſi* and Ioachimſtal: 5. The red tranſparent, cryſtallized into priſmatic decaedres, or dodecaedres, from *Hungary*, *Alſace*, and the Duchy of *Deuxponts*: 6. The *only ſuperficially red* ore, from Salberg, and *Ehrenfriedersdorf*. The Editor.

[*d*] The places where this ore appears very frequently, are *Cremnitz* in *Hungary*, *Ioachimſthal* in *Bohemia*, and the *Andreas mountain* on the *Hartz*; and each of theſe can be diſtinguiſhed by the different cryſtallizations. A peculiar variety has been found near *Ehrenfriederſdorf*, in a ſilver-vein, where it croſſes the tin-veins at Sauberg. Some of them loſe their tranſparency, eſpecially in damp places. *Brunnich.*

[*a*] This ore was ſuppoſed, by the noble Author, to contain a good portion of copper, to which the black or brown colour was attributed. But later analyſis of this ſubſtance, have ſhewn that there is no copper at all, as Mr. Kirwan aſ-

SECT. 272. (171.)

Silver mineralized by arſenic *and* ſulphur, *with* copper *and* iron.

3. With ſulphurated arſenic and copper, *Argentum arſenico & cupro ſulphurato mineraliſatum.*

ſerts in his Species 6, of which the following is the extract. This ore is either, 1. of a *ſolid* or *brittle* conſiſtence (which diſtinguiſhes it from the *vitreous-ore*) and of a *glaſſy appearance* in its fracture.

Or 2, of a *looſer* texture, and *ſooty*, or *deep black* colour.

It is like moſs, or thin leaves, lying on the ſurface of other ſilver ores, or of thoſe of *lead* and *coba t*, or in *clays*, *ponderous ſpar*, *gneiſs*, &c.

This laſt contains about 25 *per cent.* of ſilver.

And the former contains at moſt 60 *per cent.* of ſilver.

They are found in *Dauphiné*, Hungary, and Saxony.

Wallerius, in his Sp. 390, mentions the following varieties of this ore; *viz.* 1. The *ſpongious* from Siberia; and from Freiberg, which laſt produces 50 *per cent.* of ſilver.

2. That in the *powdry* form, is very rich in ſilver.

3. The *lamellated*, of a black colour, at Johan Georgenſtadt, Freiberg.

4. That in a *branched* and *dentritical* form, found in Lorraine; and

5. The *ſuperficial*, of a black colour, found at Freiberg. *The Editor.*

In Hungary this has the name of *ſilver mulm*; it has been found at Wendiſh Leuten, near Shemnitz, in Hungary, and contains 8 lb. $\frac{3}{4}$ *per cent.* of a ſilver containing ſome gold. *Brunnich.*

Minera

Minera argenti alba, the *Weiſſgulden* of the Germans [*a*].

This, in its ſolid form, is of a light grey colour, and of a dull and ſteel-grained texture. The more copper it contains, the darker is the colour. It often holds ſeven pounds of ſilver per *cent* [*b*].

N. B. The Schwartz *ſilver-ore of the laſt Section was inſerted by the Noble Author in this place. The Editor.*

Its texture is ſolid, of a light grey colour, and is that ſort properly called *Weiſſgulden*.

It is found at St. Mary among the mines in Alſatia, in the Saxon mines, and at St. Andreasberg in the Hartz [*c*].

[*a*] Mr. Kirwan ſays (Sp. 8.), that the *Weiſſgulden ertz*, or *Weiſſgulden* ore, is a heavy, ſoft, opake ſubſtance, fine grained, or ſcaly, bright and ſhining in its fractures, of a *whitiſh*, *ſteely*, or *lead-colour*; ſometimes cryſtallized in a pyramidical or cylindrical forms; but often in amorphous grains, or reſembling moſs, or in the form of thin laminæ incruſtating other bodies, found in quartz, ſpar, ſtellſtein, pyrites, blend, lead-ore, cobalt-ore, ſparry iron-ore, fluors, &c.

It is very fuſible.

Its ſpecific gravity is from 5 to 5,300.

Its proportion of ſilver from 10 to 30 *per cent.*

It is found, though not commonly, in *Saxony*, *Hungary*, the *Hartz*, and *St. Marie aux Mines*.

[*b*] This product of the Weiſſgulden, being ſo conſiderably leſs than what Mr. Kirwan mentions in the laſt note, juſtifies the errata, pointed out in Dr. Lewis's copy, in which 20 *marks*, of 8 ounces each, are put inſtead of the *ſeven pounds* of ſilver per cent. as mentioned in the text. *The Editor.*

[*c*] I have found cryſtallized white gilder-ore at *Clauſthal* in the *Hartz*, and in *Tranſylvania*; the laſt holds above thirteen marks of ſilver, containing ſome gold. *Brunnich.*

SECT.

SECT. 273. (172).

4. With ſulphurated arſenic and iron, *Argentum ferro et arſenico ſulphurato mineraliſatum.* The *Weiſertz*, or *white-ſilver ore* of the Germans.

This is an arſenical pyrites, which contains ſilver; it occurs in the Saxon-mines, and ſo exactly reſembles the common arſenical-pyrites, as not to be diſtinguiſhed from it by ſight alone; or without other means.

The ſilver it contains, may perhaps conſiſt of very ſubtile capillary ſilver [*a*] mixed in it.

[*a*] Though our Author ſuſpects that the ſilver in this ore may ariſe from ſubtile capillary ſilver mixed in it, yet it has not all the appearance of it. It is very ſcarce, and found with *miſpickel* and *plumoſe ſilver-ore*, at *Braunſdorf* near *Freiberg*.

There is likewiſe a *brown mulm*, reſembling rags, between and upon the cubic lead-ore, found at the *Dorothea-mine*, in *Clauſthal*: this contained a great quantity of ſilver, but has not yet been tried for any thing elſe. *Brunnich.*

This ore has a ſolid and hard conſiſtence, is granulated, and its colour is whitiſh and ſhining; it ſtrikes fire with the ſteel, and diſcloſes then that the arſenic enters into its maſs, by a kind of garlic ſmell; ſometimes it contains *native ſilver*, and this ſometimes *is mineralized.*

It is found not only in Clauſthal, but at Andreasberg, Braunſdorf, and Allemont, in Dauphiné. *Mongez.*

N. B. This ore is very different from that of Sect. 269. in which, according to Monnet, quoted by Kirwan, no ſulphur is contained. *The Editor.*

However,

However, I have not had an opportunity to examine this circumſtance.

SECT. 274. (173.)

5. With ſulphurated antimony, *Argentum antimonio ſulphurato mineraliſatum.*

a. Of a dark-grey, and ſomewhat browniſh colour.

The *Leberertz* of the Germans; from *Braunſdorff* in *Saxony.*

b. Of a blackiſh blue colour.

1. In form of capillary criſtals, *Minera argenti antimonialis capillaris.* The *Federertz* of the Germans, or *plumoſe ſilver ore* [*b*].

It is found in Saxony, and contains only two or four ounces of ſilver per cent.

SECT.

[*a*] There is a *brown-ſilver*-ore, called Leber ertz alſo, by the Germans, which contains *arſenic*, and *regulus of antimony.*

The colour of this ore is of a reddiſh brown, ſometimes dark grey. It is found alſo cryſtallized into pyramids: but for the moſt part it is amorphous.

When ſcraped it appears red.

It contains from 1 to 5 *per cent.* of ſilver.

The greateſt part of this ore is copper, and the next in proportion is arſenic. *Kirwan*, Sp. 10.

The copper in this ore amounts to 24 in the *hundred.* It is found at Dal. *Berg. Sciag.* 170. In Tranſylvania, and lately at Altheire in Grenada of Spain. This was of a hard ſolid conſiſtence, and of a greyiſh blue. *Mongez.*

[*b*] Sometimes it contains a mark, *i. e.* half a pound of ſilver *per centum.* It is likewiſe found ſometimes to contain a very trifle of ſilver only. *Brunnich.*

There

SECT. 275. (Additional.)

Silver, with iron, arſenic, and cobalt, mineraliſed by ſulphur.

This ore looks like the *Weiſſgulden*, (Sect. 272), excepting that the cobalt, by its decompoſition, gives it a roſy appearance. There are two varieties of this ore; one of a dull, tarniſhed ſurface, and of a ferrugineous look.

The other variety has a ſhining appearance, like the fracture of the ſilver-grey ore of the preceeding Sect. 274.

This ore produces ſome times 10 *per cent.* of ſilver. It is to this ſpecies of ores, that the *ſilver gooſe-dung ore* belongs. *Berg.* and *Mongez.*

It is diſtinguiſhed by the roſe-coloured particles of cobalt, diſperſed through a *dark brown, blackiſh*, or *grey*, and ſometimes *ſhining* ſolid maſs.

It is found in *Saxony*, and at *Allemont* in *Dauphiné.*

There is another ore called *Leberertz*, in Germany, which contains *arſenic* beſides the *ſulphur*; and the antimony is in a reguline ſtate. This ore, in point of colour, varies from a *dull white* to *grey, dark blue, brown*, or *black.*

It is found in a capillary form, or like wool, ſometimes looſe, at another time *attached.* Its filaments are rigid and inflexible. The whiter it is, the richer; but it ſeldom contains *one per cent.* of ſilver. *Kirwan*, Sp. 11.

It

It contains about 40 or 50 *per cent.* of ſilver, and very little cobalt. The arſenic is in an acid ſtate, and united to the cobalt. *Kirwan, Sp.* 12.

SECT. 276. (174.)

6. With ſulphurated copper and antimony, *Argentum cupro & antimonio ſulphurato mineraliſatum.* The Dal *Fahl-ertz* [*a*].

This reſembles, both in colour and texture, the dark-coloured *Weiſſgulden*, or *Falerts*. When rubbed, it gives a red powder.

a. Solid.

b. Criſtalliſed, is found in the pariſh of *Aminskog*, in the province of *Dal*; and at that place has been for ſeveral years melted by a method invented for the

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[*a*] There is another like the above, under the ſame name, which contains arſenic, beſides the other component parts.

This is a hard grey, or dark grey ore, more or leſs brilliant; ſometimes cryſtallized, but moſtly amorphous. In fact it is the *grey-copper ore* (of which in its place) impregnated with ſilver, which it contains from 1 to 12 *per cent.* and from 12 to 24 of copper, the remainder being ſulphur and arſenic, with a little iron. The richer it is in copper, the poorer it is in ſilver, and reciprocally.

Mr. Monnet remarks, that wherever copper is united to arſenic, ſilver is alſo found.

This is the commoneſt of all the ſilver ores. *Kirwan.*

Another variety of this ore has been found at *Schsnitz*, which contains ſome gold, beſides the ſilver. The grey-ſilver ore is ſometimes black, and is called *Schwartz guldenertz*, by the Germans, and *Negrillo* by the Spaniards. *Mongez.*

different

different mixture of the ores; which proceſs muſt be very troubleſome to thoſe who are not perfectly well verſed in metallurgy.

It contains thirteen ounces of ſilver, and twenty-four per cent. of copper.

SECT. 277. (175.)

7. With ſulphurated zink, *Argentum zinco ſulphurato mineraliſatum.* The *Pechblende* of the Germans.

This is a zink-ore, mock-lead, or blende, which contains ſilver, and is found among rich ſilver and gold ores; for inſtance, in the Hungarian and Saxon mines.

a. Of a metallic changeable colour.

1. Solid, and with fine ſcales.

2. In form of balls. The *Kugelertz*, or *Ball-ore*. It is found at *Shemnitz*, and contains alſo gold. Its yield of ſilver is twenty-four ounces per cent. and thirty per cent. of zink [*a*].

b. Black *mock-lead*, or *blende*, found in Saxony. This is alſo found,

1. Solid, and in fine ſcales;

2. And in form of balls.

[*a*] At preſent they know nothing of the *globular blend*, and *globular-ore* there. In Bohemia, near *Joachimſthal*, there is a *black-blend*, which is very heavy, and whoſe ſurface is elevated, like ſome kinds of *hæmatites*, but they have not been able to get any ſilver out of it. *Brunnich.*

SECT.

SECT. 278. (176.)

8. With ſulphurated lead. Potters ore. *Galena.* Bleyglanz, *Germ.* *(See Sect.* 188. *of the Author.)* [*a*].
9. With ſulphurated lead and antimony, called *Striperz.* *(See Sect.* 190. *of the Author).*
10. With ſulphurated iron, *argentum ferro ſulphurato mineraliſatum.* *Silberhaltiger-kies,* marcaſite holding ſilver [*b*].

At *Kongsberg*, in Norway, it is ſaid, a *liver-coloured marcaſite* is often found, particularly at a mine called *Fraulein Chriſtiana*, &c. This marcaſite contains of ſilver, from three to three ounces and a half *per cent.* [*c*].

[*a*] This ore is called alſo *Pyritous Silver.* It is of a brown colour. It produces a very ſmall portion of ſilver: and it is found at Kungsberg in Norway. *Mongez*, § 164. A.

[*b*] This ore produces *half an ounce* of ſilver *per cent.* There are great varieties of this ore, and many produce a conſiderably larger quantity of ſilver. *Bergs and Mongez.* § 165.

[*c*] The Hungarian *gilf*, which contains gold and ſilver, will doubtleſs be found to contain ſome iron, though its conſtituent parts are not yet ſufficiently examined.

11. With ſulphurated and arſenical cobalt. *Argentum cobalto ſulphurato & arſenicato mineraliſatum.* Is found at *Morgenſtern* near *Freyberg* and *Annaberg.* Sometimes there are *dendrites* in the ſtone. Theſe kinds generally wither in the air, and loſe the ſilver they contain. In water they keep very well. *Brunnich.*

SECT. 279. (Additional.)

Silver mineralized by *Sulphur*, with *Regulus of Antimony* and *Barytes*.

The Butter-milk Ore.

This is found in the form of thin particles, on granular Spar. *Kirwan*, *Sp.* 13.

Perhaps is the ſame deſcribed by Wallerius, p. 346. of his ſecond volume, by the words *lutoſa*, *obſcura*, *pinguis*. He ſays, that this ore is ſoft like *mud*, and feels like *butter*; and ſuſpects to be produced from other ſilver-ores, which are waſhed away by the running waters. Bomare adds, that the miners look upon it as a certain ſign of being arrived in the vicinity of the rich ore; but ſome others are ſingularly perſuaded, that it is a green or unripened ſilver-ore, which will ſoon become a perfect ore, &c. *The Editor.*

SECT 280. (Additional.)

Combuſtible Silver-ore.

This is a black and brittle ſubſtance, and leaves about 6 *per cent.* of ſilver in its aſhes. It is in fact a coal, in which ſilver is found. *Kirwan*, *Sp.* 14. Lehmann ſpeaks alſo of ſilver found in coal-matrices. *Journ. de Phyſi.* for March 1779, p. 183.

SECT.

SECT. 281. (177.)

The Horn-ſilver-ore.

12. With the acid of common ſalt, *argentum acido ſalis ſolutum et mineraliſatum. Minera argenti cornea.* Hornertz, or *Horn-ſilver-ore* [*a*].

This is the ſcarceſt ſilver ore; it is of a white or pearl colour, changeable, or varying on

[*a*] It is ſometimes found in ſnowy cubic cryſtals, of which the academy at Freyberg have a fine ſpecimen. In 1747, were found many pieces of it at *Ober-Schöna. Brunnich.*

This ſcarce and valuable ore is either of a *white*, *grey*, *pearly*, or yellow, green, brown, purple, and black colour. Its principal character is its change into a *violaceous* browniſh colour, when expoſed to the Sun's beams, as it happens alſo to the artificial *horn-ſilver*.

It is frequently cryſtallized in a cubic form; ſometimes it reſembles an earth, eaſily fuſible without ſmoke: the black ſort is friable, and eaſily pulveriſed; but the other ſort is in ſome degree malleable, may be cut with a knife, and takes a ſort of poliſh when rubbed.

The *vitreous-ore*, which is ſometimes mixed with the *black-horn-ſilver*, is ſoluble in nitrous acid: and may, by that means, be ſeparated, the ſaline only being inſoluble in that acid.

When the horn-ſilver is pure from iron, it contains *70 per cent.* of ſilver at leaſt; but theſe ores moſtly contain ſome portion of iron, of which ſome is even united to the marine acid, according to Monnet.

This ore is found in *Bohemia*, *St. Marie aux Mines*, *Siberia*, *Allemont* in *Dauphiné*, *Johan Georgenſtadt* in *Saxony*, *Guadal-canal* in *Spain*, and in *Peru*.

on the ſurface, ſemi-tranſparent, and ſomewhat ductile, both when crude, and when melted. It cannot be decompoſed without ſome admixture of ſuch ſubſtances, as attract the acid of the ſea-ſalt. It is found in very thin worked or wrought leaves or cruſts, at *Johan Georgenſtadt*, in *Saxony*.

SECT. 282. (Additional.)

Silver Gooſe-dung ore.

This is of a greeniſh colour, mixed with yellow and red. It is ſaid to contain about 6 *per cent.* of ſilver. Some think it a mixture

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It was firſt eſſayed by Mr. P. Woulfe. *Phil. Tranſact. for* 1776, and afterwards, though leſs exactly, by Mr. Monnet.

Mr. Woulfe was the firſt who diſcovered in this ore the preſence of the vitriolic acid.

Profeſſor Bergman, in his *Sciagraphia*, § 162. mentions another kind of horn-ſilver, mineralized by the *vitriolic* and *muriatic* acids, and *ſulphur*. He doubts whether this be a different ſpecies of ore, ſince the ſulphur and the ſalt ſcarcely admit of any other than a mechanical union. But ſince iron is often found, though in a ſmall quantity, in theſe ores, it may form a marcaſitical mixture therewith. Mr. Mongez aſſerts, that iron is certainly contained in the *horn-ſilver* ore that is found in Saxony, which is the impureſt of the kind. But Wallerius, in his uſual way, contents himſelf with diſtinguiſhing, by the external appearances of colour, the three following varieties; *viz.* the *whitiſh* horn-ſilver, found in *Zellerfeldt*, and in *Guadalcanal*; the *yellowiſh-brown*, which reſembles *colophony*; and the *purple-green* found at *Georgenſtadt* in Saxony. *The Editor from* Kirwan, Bergman, Mongez, &c.

of

of red ſilver ore, and calx of Nickel. *Kirwan, Sp.* 16.

Every one may eaſily obſerve, that Wallerius, Bomare, Romé de l'Iſle, and other mineralogiſts, have given various names to ſome *ſilver ores*, whoſe contents are not quite different from one another; ſo that it ſeems rather probable they have been led by a whim of nomenclature from which no uſeful information can be gathered by their peruſal. *The Editor.*

SECT. 283. (Additional.)

Foliaceous Silver ore. *Silberartiges, Bergzunder. Blatter erez.* in German.

Its colour is *mortdoré*. Some think it to be a *native ſilver ore*; others take it to be a mixture of *galena, ochre*, and *ſilver*.

This ore is found ſometimes in the Mountain-cork (Sect. 69), and is ſo light, that it may ſwim on water. It contains but *one ounce* of ſilver *per quintal*. *Kirwan, Sp.* 17.

SECT. 284. (178.)

Obſervations on the Silver-ores.

Silver may, perhaps, be found mineraliſed in the like manner with other metals than theſe here enumerated, ſuch as with cobalt

and biſmuth; but having no certain knowledge of ſuch mineralizations, I omit them here [a]. It would be worth examination, if in thoſe mine countries where gold and ſilver are found in quantity, other ores do not contain a little of thoſe metals, more eſpecially when the particles of ſilver and gold have not been able to extricate themſelves from the other minerals, and lie ſeparate from them in the *fiſſures*, *veins*, and *ſhakes* or *wranks*, that is to ſay, in the hollow places in the mines.

Thoſe ſilver-ores which are named from earth or ſtones, wherein the ſilver is found; as, for inſtance, in the *Gooſe-dung ſilver ore*, and the *Leberertz*; ought no more to be conſidered in a natural ſyſtem than other diſtinctions which are uſed at mineral works, and are only names given to the ores, according to the ſeveral changes they undergo to make them fit for the melting proceſs [b].

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[a] Our author doubts whether ſilver is ever found mineralized with *cobalt* and *biſmuth*; but the ores from *Scheeberg* and *Annaberg*, are convincing proofs of it.

Silver has alſo been found in an amalgama with quick-ſilver, in the mines of Salberg. *J. R. Foſter.* See Note *a* to Sect. 267.

[b] Notwithſtanding this well-founded obſervation of our Noble Author, many mineralogiſts have made long catalogues of ores, whoſe varieties only conſiſt in mere accidental circumſtances. Wallerius, in his Spec. 401. has made numerous articles of the different colours and earths, with which the ſilver ores are found; a ſmall part of which have been ſeen in Note *b*, to Sect. 267. *The Editor.*

A mi-

A mineraliſation of ſilver with alcali has been recently mentioned: it is ſaid to have been found at *Annaberg* in *Auſtria*. But this diſcovery, which is made by a mine-maſter, Mr. Von Juſti [*c*], requires an explanation, ſince the author, in his deſcription, does not obſerve the neceſſary diſtinction between alcali and lime; and quotes the *horn-ſilver ore*, and the *luna cornea*, as proofs of his opinion; by which, however, his opinion ſeems rather weakened than confirmed.

SECT. 285. (179.)

Platinum Linnæi.

Platina. White gold. Platina del Pinto, or *Juan blanco* in Spaniſh.

This metal is a recent diſcovery of our times, and is deſcribed with great accuracy by Scheffer, in the Acts of the Royal Academy of Sciences at Stockholm, for the year 1752; as alſo by Dr. Lewis, in the Philoſophical Tranſactions for the year 1754, vol. xlviii [*a*]. And though theſe two gentlemen agree

[*c*] The ſilver in the alcaline lime-ſtone of Mr. Juſti, from *Annaberg*, is native, as appears when it is poliſhed. *Brunnich.*

[*a*] Mr. Macquer ſays, that in the year 1741, our countryman, Mr. Wood, brought to England from Jamaica, ſome platina, which was ſaid to come from *Carthagena*, in the

agree in the principal circumſtances relating to this metal, yet it is very plain by their deſcriptions, that neither of them knew any thing of the other's experiments. By theſe deſcriptions we are convinced of the reſemblance this metal bears to gold; and therefore we muſt allow it to be called *white gold*, though, both theoretically and practically, it may be diſtinguiſhed from gold by the following qualities.

1. It

Spaniſh Weſt India; and that he had made ſome good eſſays of it. That in the year 1744, ſome vague accounts were publiſhed of this ſubſtance by Mr. Ulloa, in the printed account of his voyage with the French academicians to Peru, for meaſuring a degree of the earth near the Equator; and that he (Mr. Macquer) had worked with Mr. Baumé on this new metal, for which purpoſe he quotes the Memoirs of the Academy of Sciences for the year 1758.

Alonzo Barba, a Spaniſh metalurgiſt, quoted by Bomare, ſpeaks of a mineral, called *Chumpi*, ſimilar to the Spaniſh emery, and found among the red and blackiſh gold and ſilver mines at *Potoſi* and *Choyaca*, in the Spaniſh Weſt Indies, which was preſumed to be the true *native platina-ore*. This emery was called *Gold* or *Silver Emery*, and is now extremely rare in Europe.

But the moſt ſatisfactory account we have of the mines of Platina, is that given in the *Journal de Phyſique*, for November 1785, under the ſignature M. L. It is at *Novita* and *Citara*, on the North of the Province of *Choco*, in the Spaniſh Weſt Indies, that platina is found, more or leſs mixed with particles of gold; when theſe are too ſmall to be picked out by hand, they are ſeparated by amalgamation with mercury, as commonly uſed in ſimilar caſes; and from this operation proceed thoſe little globules of mercury, found ſometimes with platina; but not that they be naturally found together. In fact, there is not in the whole Spaniſh America any other

1. It is of a white colour.
2. It is ſo refractory in the fire, that there is no degree of heat yet found, by which it can be brought into fuſion by itſelf, the burning-glaſs excepted (ſee the Note p. 573). But, when mixed with other metals, and ſemi-metals, it melts very eaſily, and eſpecially with arſenic, both in its metallic form, and in form of a calx or glaſs.

3. It

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mines of mercury, but at *Guancavelica*, in the Peru, at the diſtance of above nine hundred miles from *Choco*; and it is further confirmed, by obſerving, that no ſuch globules of mercury can ever be diſcovered in thoſe parcels of Platina brought to Europe, when ſome particles of gold are mixed with it; this laſt being the true ſtate of the native Platina, ſuch as it is found in the ground. Theſe mines are of the ſecondary kind, being found in ſtrata of looſe earth, that have been waſhed off from higher grounds. But the primitive or original mines, where platina has been produced, have not yet been diſcovered in any part of the globe.

The quantity of gold particles, intermixed with platina, is ſometimes ſo inconſiderable, that it is not worth the expences attending the amalgamation with mercury. Very often it contains, 2, 3, 4, and more ounces of *platina* in the pound of *gold*; and what is remarkable, both theſe metals are conſtantly of the ſame form.

Platina is always found in the form of very ſmall particles, from the minuteſt ſand ſize to that of a common pea; although this laſt is very ſeldom to be met with. The above M. L. ſays, that he had ſome native particles, or pieces of platina, which weighed from 15 to 20 grains; and adds, that on trying ſome of theſe between ſteel-rolers, in the preſence of Meſſieurs Tillet and Darcet, at Paris, they were perfectly laminated, which evinces, that platina, in its native form, is malleable. The ſame Naturaliſt adds, that a native piece of platina was found nearly of a ſquare figure, almoſt as big

as

3. It does not amalgamate with quickſilver by itſelf, but only by means of the acid of common ſalt after a long trituration. This metal ſeems therefore really ſeparated from gold by amalgamation, at thoſe places where it is found; and, without this quality, it would be very difficult to ſeparate it.
4. It is harder and leſs coherent than gold.
5. It is heavier than gold; and therefore the heavieſt of all bodies hitherto diſcovered. For though the ſpecific gravity of platina, in the hydroſtatical experiments made by Dr. Lewis, is found to be to water only as 17,000 or 1600; yet, when melted with

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as a pigeon's egg, which was depoſited in the Royal Society, at Biſcaya, which muſt be the ſame, known by the name of *Baſcongada*, or the *Society of the Friends of their Country*. But the common ſize of the particles of native platina, hardly exceeds that of a millet corn; and almoſt every one is of an oblong form, very flat, round edged, with a ſmooth ſurface, and of a whiter colour than iron; but always intermixed with black ferrugineous ſand. Moſt of its particles are friable, and magnetic: thoſe which remain after the ſeparation, operated by means of the magnetic bars, ſtill contain about one-third part of iron, according to the experiments of the Count de Sickingen.

I had the opportunity of examining a large parcel of platina (about 72 pounds troy weight) brought from Spaniſh America, among which I found not only a great quantity of ferrugineous ſand, but many bits of vegetable ſtalks and ſeeds, and alſo ſome very ſmall red cryſtals, like rubies. Theſe laſt I ſent to Mr. Achard, the ingenious and celebrated chemiſt of Berlin, who tried them as far as their minuteneſs and ſmall quantity could permit; and concluded they were real rubies. *The Editor.*

other

other certain metals, its ſpecific gravity has, by an exact calculation, been found to be conſiderably augmented, even ſo much as to 22,000 [*b*].

6. Diſſolved in *aqua regia*, and precipitated

[*b*] According to Mr. de Morveau, the ſpecific gravity of platina, reduced to a metallic maſs, by the proceſs of M. de l'Iſle, which is the ſame of Count de Milly, mentioned in the next note [*d*], is - - - - - - 10,0353

That of native platina in grains, according to the Naturaliſt M. L. above-mentioned, is - - - 15,6017

That which is not attracted by the load-ſtone, according to the ſame M. L. is - - - - - 16,2519

And that purified by the muriatic acid, according to the ſame Author, is - - - - - - 16,7521

But according to Morveau, *native platina* in grains, has the ſpecific gravity of - - - - - 16,6870

According to our Author Cronſtedt, it is - - 17,0000

According to Bergman in his *Sciagraphia*, - 18,0000

When reduced into a metallic maſs, and well hammered, according to Morveau, it is - - - 20,1700

Finally, Dr. Withering mentions, that by ſome late experiments, made by Count de Sickingen, and publiſhed in German, by Profeſſor Succow; the ſpecific gravity of *pure platina*, ſeems to be - - - - - - - - 21,0000

One of thoſe ſpecimens I received from the late Count de Milly, which he rendered malleable by the proceſs hereafter mentioned, in Note [*d*], being nicely examined by Mr. Nicholſon, in a very good hydroſtatical balance, ſhewed its ſpecific gravity to be, *in the temperature of* 60 *degrees of Fahrenheit's thermometer* - - - - 21,370

Another ſpecimen of the ſame, which was not magnetic, being examined alſo by Mr. Nicholſon, after it had been melted by Parker's lens, and well hardened with a hammer on the anvil, ſhewed in the ſame temperature, - - 22,700

Finally, Mr. Kirwan, p. 239, of his Mineral. ſays it to be 23,000

The Editor.

with

with tin, or with a ſolution of that metal, it yields no *purpura mineralis* [c].

Except

[c] This metal is ſoluble in *aqua regia*, as is likewiſe gold: and in the muriatic acid, when dephlogiſticated, which, in that ſtate, diſſolves every metal: and perhaps in the vitriolic acid alſo, when diſtilled upon manganeſe; no other acid acts upon platina, without its having undergone a previous calcination. But its precipitation, by volatil alkali, does not fulminate: neither does it produce a purple powder with tin, as our Author has obſerved.

The ſolution of Platina in *aqua regia*, is at firſt yellow, but when further loaded grows red, and of a proportionally deeper colour. Upon evaporation, cryſtals are formed of a deep red colour, frequently opake, but ſometimes pellucid, very ſmall and irregular, reſembling angular grains, which, when waſhed, require far more boiling water, than gypſum does, for their ſolution.

A ſmall quantity of vegetable alkali precipitates a different ſort of octoedral cryſtals, ſoluble in water; and a larger quantity precipitates a yellow ſpongy powder, inſoluble in water, which is the calx of platina. This may be diſſolved more or leſs in all the known acids.

The celebrated Margraaf denied, that the ſolution of platina could be precipitated by the mineral alkali; and Dr. Lewis confirmed this aſſertion, upon his own experiments. But Bergman found that by pouring a large quantity of its ſolution, and ſtill better by employing the dry and ſpontaneouſly calcined mineral alkali, the genuine calx of platina was precipitated.

Platina is precipitable from its ſolution in *aqua regia*, by *ſalt ammoniac*, as our late learned chemiſt Dr. Lewis diſcovered; this is a property by which this metal may be eaſily diſtinguiſhed and ſeparated from all others.

Lime alſo, whether aerated or cauſtic, precipitates likewiſe platina from its ſolution, as well as the mineral alkali.

It may be purified from iron by reiterated coction in marine acid; ſolution in *aqua regia*, and precipitation by the pureſt ſal ammoniac; for platina is not precipitable by the *Pruſſian*

Except theſe, this metal has the ſame qualities as gold; but it cannot, on account of its refractorineſs in the fire, be worked off pure on the cupel, neither can it be worked with antimony; becauſe, before it is rendered perfectly pure, it cools, grows hard, and retains always ſome part of the added metals [*d*].

It

Pruſſian (or *phlogiſticated*) *alkali*, as all other metals are, nor by the ſolution of the *vitriol of iron*. By theſe two precipitants the mixture of any *iron* or *gold*, that may ſtill remain in the ſolution of platina in *aqua regia*, may be firſt ſeparated, before its being precipitated by the ſolution of ſalt-ammoniac, and the platina may then be had perfectly pure. *The Editor, chiefly from* Bergman *and* Kirwan, &c.

[*d*] Platina, when perfectly pure in its metallic ſtate, ſays Dr. Withering, is not calcined by deflagration with nitre.

It does not admit of being hardened or ſoftened, by tempering like ſteel or other metals.

It has been drawn into a wire of $\frac{1}{1940}$ of a line in diameter. This wire admitted of being flattened, and had more ſtrength than a wire of *gold* or *ſilver* of the ſame ſize. *Withering.*

N. B. I ſuſpect this to be the $\frac{1}{1940}$ of an inch, as no ſuch wire as here mentioned can be made. *Editor.*

Platina is not fuſible by the ſtrongeſt fire, but melts in the focus of a ſtrong burning lens.

I have ſeen at Paris, that the great burning lens, of which the late generous Mr. Trudaine made a preſent to the Royal Academy of Sciences of Paris, and whoſe coſt amounted to about one thouſand pounds ſterling, only agglutinated its particles in 20 *minutes*. But Mr. Parker's burning lens, in London, perfectly melted them in leſs than *two minutes*. This laſt burning lens is of ſolid *flint-glaſs*, about 3 feet diameter; but the French was made of two glaſs-curved-plates, of 4 feet diameter, and filled with about 40 pints of ſpirits of wine. I am told that this coſtly inſtrument has been lately broken by ſome accident or other. *The Editor.*

From

It is brought to us only in its native ſtate, in ſmall, irregular, rugged grains; and it is yet uncertain

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From conſidering the very intereſting experiments of the Count de Sickingen, I apprehend the following method, to obtain pure and malleable platina, will be found a good one.

Diſſolve the grains of native platina, that are leaſt magnetic, in *aqua regia*: precipitate the iron by means of phlogiſticated fixed alkali: then precipitate whatever elſe will fall, by cauſtic vegetable alkali: ſaturate the liquor with cauſtic foſſil alkali, and ſet it by to cryſtallize: the yellow cryſtals thus obtained, are to be hammered together at a welding heat, and the metallic parts will unite. *Withering on the* Sciagraphia of Bergman.

Platina, however, may be reduced otherwiſe to a malleable ſtate. The method which the late Count de Milly employed at Paris, and which whole operation he was ſo obliging as to do in my preſence, and at my requeſt, is as follows: 1ſt, he ſeparated all the ſand and other heterogeneous particles, by blowing them out whilſt the grains of platina were letting down from one paper to another paper. He put the metal in a matraſs, with 20 times its weight of *aqua regia* on a ſand heat; the next morning decanted it from a ſediment, compoſed of ſome whitiſh particles, of a metallic appearance, mixed with a blackiſh matter, which he told me was a molybdenic ſubſtance. He then mixed with it an equal quantity of diſtilled water: precipitated the platina by a ſolution of ammoniacal ſalt; and he filtrated the liquor through blotting paper; this, and the reſidue being dried in a plate over the fire, was put on a Heſſian-crucible, which he guarded within another larger crucible. This was covered with a teſt, and put on a blaſt furnace, till it was red hot, even to a white heat, during *half an hour*; he then opened the crucible, where I ſaw the metallic ſubſtance, like a filamentous maſs; this he preſſed down with an iron rod, whoſe end was formed into a flat button: he covered it again, and continued the fire for ten or twelve minutes; the crucible being taken out, the ſolid maſs was connected at the bottom: could be forged, and beaten, on the anvil with the hammer, into any form, like iron.

uncertain whether it is found naturally mineraliſed. The Platina is brought to Europe from

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iron. I have ſome ſmall ſpecimens of this metallic maſs, which do not differ in colour from ſilver; and I have alſo ſome that was flattened between the rollers, and is very ſpringy: all theſe are attracted by the load-ſtone: but on my expoſing a bit of this bar of platina to the focus of Mr. Parker's burning lens, it eaſily melted, retained its perfect mallability, and loſt its attraction to the magnet: while the buttons, that had been fuſed of the grained platina, by the ſame lens, were not malleable, but very brittle under the hammer.

The chemiſts of Dijon ſay, that they have fuſed, very eaſily, platina in a ſtrong blaſt furnace, by means of their new flux, by which iron, and all other hard metals, may be fuſed alſo, to the great advantage, as Mr. Tillet has tryed on the calces of copper, from which he got five *per cent.* more than by the *black flux*, though helped by tallow. This new flux conſiſts of 8 parts of *powdered glaſs*, one of a *calcined borax*, and half of *powdered charcoal*. But they do not ſay whether the platina, after being ſo fuſed, was perfectly malleable, and fit to be worked to any advantage.

Platina may be alloyed with all metals, and fuſed with them in various proportions; but theſe mixtures are not ſuch as to offer any advantages, being either too hard, or ſo imperfect, as to ſhew a very coarſe grain. That with gold ſeems the beſt of all.

It is ſaid, that the Spaniſh miners in America, have the art of treating platina, with a ſmall quantity of ſulphur and arſenic, ſo as to melt it eaſily, for making various pieces of uſe, as *ſnuff-boxes*, &c.: but I never heard of ſuch pieces being brought to, nor ſeen in Europe.

According to the above quoted Mr. Bomare, in his *Mineralogy*, platina is eaſily fuſed by means of ſulphur or arſenic: but he does not ſay that he has ſeen the operation tried. And Mr. Macquer aſſerts, that this metal may be fuſed by the addition of *liver of ſulphur*, as gold may alſo by the ſame means.

Mr. Achard, the famous chemiſt of Berlin, diſcovered an eaſy method of fuſing platina, ſo that crucibles, and other utenſils

from the *Rio del Pinto*, in the Spaniſh Weſt-Indies. *See Note* [*a*].

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utenſils of this unalterable metal, may be made without great trouble, for chemical purpoſes. The Author communicated it in a letter he wrote to me on the 18th of February, 1784. It conſiſts in mixing, with *platina*, an equal weight of *white arſenic* in powder, and as much of *ſalt of tartar*. The mixture is expoſed in a crucible to the heat of a wind furnace: it ſoon fuſes together; and being thrown on an iron plate, the metal, when cold, is very brittle; it is then pounded in a mortar; and, having prepared a proper mould of very refractory clay, it is filled with the metallic powder, and expoſed to a violent fire of copellation, till the arſenic be entirely evaporated. By theſe means the metal remains in its metallic form, with the very figure of the mould. Mr. Crell has publiſhed this proceſs in his *Chemical Journal*; and the ſame was inſerted in *Journal de Phyſique*, for June 1786, page 456. Mr. de Morveau has given alſo an account of his experiments on this ſubject, in the Memoirs of Dijon for 1785, page 106, and ſays to have ſucceeded, by making, in this method, ſome improvements. He ſays, that the *arſenic* and *ſalt of tartar* produced an overboiling froth, which ran off from the crucible; and that the arſenical fumes were very troubleſome. But my friend, Mr. Babington, has fuſed in my preſence, and at my requeſt, *two ounces of platina*, in a wind furnace, at the Laboratory of Guy's Hoſpital, obſerving with care the above directions of Mr. Achard; and there was not the leaſt inconveniency of the arſenical fumes, theſe being immediately droven up the chimney, whenever the teſt or cover was taken from the crucible, to examine the going on of the operation; nor was there obſerved any overboiling froth, &c. A lump of the metal was produced by the firſt operation, which was of a fine grain; but very brittle. Mr. William Cooper undertook alſo this proceſs at my requeſt, and the event was the ſame; even after he urged the fire for above two hours, to the 162 degree of *Wedgwood's thermometer*, the brittle lumps only became harder, but by no means malleable, as by the above proceſs of Count de Milly: and the ſame happened to another like lump of platina expoſed by Dr. Pearſon, to the greateſt heat of his wind-furnace. *The Editor.*

SECT.

SECT. 286. (216.)

Quickſilver, Mercury. *Hydrargirum, Argentum vivum, Mercurius.* Lat.

General properties of Quickſilver.

Mercury diſtinguiſhes itſelf from all metals, by the following qualities [*a*].

a. Its colour is white and ſhining, a little darker than that of ſilver.

b. It is fluid in the cold, and diviſible by the leaſt force; but, as it only ſticks to a few

[*a*] 1. It were almoſt ſuperfluous, ſays Mr. Kirwan, to mention any other character of quickſilver, than its liquidity, to diſtinguiſh it from other metals. In regard to this property, Bergman obſerves, that Mercury conſtitutes one extreme among the metals, and Platina the other; ſince it requires to be melted, only ſuch a degree of heat, as is rarely wanting in our atmoſphere, and boils at the 600 *deg.* nearly after lead melts. *See the* Table *at p.* 509. But, when the cold is increaſed to the temperature, denoted by 40 degrees below *nought* both of Farenheit's and of the Swediſh thermometer, which both coincide in that point (ſince 212 − 32, *or* 180 : 100 : : 32 + 40, *or* 72 : 40), this metal concretes like any other metal; becomes quite ſolid and malleable like lead. The accurate experiments, made by Mr. Hutchins at Hudſon's-Bay, on this metal, as related in the Philoſ. Tranſactions, for the year 1783, p. 303. have proved this fact beyond all controverſy. Mercury, in its common ſtate therefore, as the ſame Bergman pronounces (in his Treatiſe of *Elect. Attract.*) is to be conſidered as a

few bodies, to which it has an attraction, it is ſaid that it does not wet.

It

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metal in fuſion; and ſince, in its ſolid ſtate, it is nearly as malleable as lead, it by no means ought to be placed among the ſemi-metals, otherwiſe every other intire metal ſhould be conſidered as brittle, for none is maleable when in fuſion.

2. Quickſilver is as *opake* as any other metal. Its *ſpecific gravity* is the neareſt to that of gold itſelf. Its *indeſtructibility* by fire, air, water, or other agents, and its *reducibility*, or power of recovering its metallic ſtate, with all its former properties, by itſelf alone, in the fire, are as compleat as thoſe of the *perfect metals*. Boerhaave had the patience, as Dr. Lewis ſays, of diſtilling *eighteen ounces* of mercury 511 times ſucceſſively, and it was not altered in any degree; it only appeared to him a little more brilliant, heavy, and fluid, which ſurely depended only on a very compleat purification, as Fourcroy remarks. See note *b*, N° 5, to Sect. 296.

3. The ſame Boerhaave kept mercury in a conſtant agitation for many months; digeſted it, for upwards of 15 years together, in low degrees of heat, both in open and cloſe veſſels, by itſelf, and in conjunction with other metallic ſubſtances; and received from all his labours only this reſult, that mercury is not, by any of thoſe means, to be changed at all, as the ſame Dr. Lewis obſerves.

4. It is true that mercury may be calcined by heat alone. For this purpoſe it is put into matraſſes, with long necks and flat bottoms, that the mercury be there ſpread with a large ſurface and a ſmall depth: the necks are drawn into capillary tubes, by the flame of a lamp with a blow-pipe; and their ends are left open, or broken, to leave a communication with the external air: the matraſſes are then expoſed to a boiling heat in a ſand-bath for night and day: in about 15 or 20 hours, ſome *red powder* is formed, and ſeen ſwimming on the ſurface of the mercury; but the proceſs is continued for weeks and months, to increaſe the quantity. This is wrongly called *Precipitate per ſe*, it being only a real metallic calx; and as ſuch, cannot be formed without the communication of the external air. It is *ſpecifically* lighter, though its *abſolute weight* is increaſed by $\frac{1}{15}$ above that of the mercury employed in the calcination; and

contains

c. It is volatile in the fire [*b*].

d. Its

contains the *pureſt air*, firſt diſcovered and named *dephlogiſticated*, by Dr. Prieſtley. But this very calx may be reduced again, like that of *noble metals*, into perfect running quickſilver, without the addition of any other phlogiſtic ſubſtance, notwithſtanding it is ſo fixed, that it may be expoſed to the moſt violent fire without loſs; and may even be vitrified, as Keir, the Engliſh tranſlator of Macquer's Dictionary, poſitively aſſerts.

5. By a heat no greater than that of the human body, or even of boiling water, though continued for ſome years, only a ſmall portion of the mercury is converted into a dark greyiſh or black powder, called *Æthiops per ſe*. Conſtant triture, or agitation, produce the ſame effect in a far ſhorter time. This powder is alſo revived by heat, without any other addition. *See note* [*b*].

It is then evident, that there cannot be the leaſt heſitation for ranging mercury among *entire metals*, as Bergman, Cramer, Linnæus, Fourcroy, and other mineralogiſts have done. But the Academicians of Dijon (vol. I. p. 114.), and Mr. Kirwan (p. 227. of his Elem. of Mineralogy) claſſed Quickſilver among the *perfect metals*, to which opinion I very willingly ſubſcribe. Notwithſtanding the Noble Author had left it among the *ſemi-metals*, which I can attribute only to his modeſty, for not contradicting the moſt general opinion of his contemporaries; although he had expreſſed his mind rather to the contrary at the beginning of the Note [*a*] to Sect. 260. p. 506.

[*b*] The volatility of this metal is ſuch, that even in the temperature of the atmoſphere, little globules of mercury are ſometimes gathered from its emanations in the inſide top of the tubes of barometers. Mercury being incloſed in a ſtrong box of iron, and the joints well ſoldered together, was put on the fire of a furnace, to try whether it could be fixed according to the expectation of the alchymiſts: the event, however, ſhewed, that it was reduced into vapours of ſuch an expanſive force, that it exploded with the utmoſt violence, tearing the iron into pieces, and every thing it met with in its way. This happened in the laboratory of Mr. Geoffroi junior; and Mr. Beaumé was witneſs to the accident, as Mr. Macquer relates in his *Chymical Dictionary*. The Editor.

d. Its weight is next to that of gold, viz. to water, as 13,593 : : 1000 [*c*].

e. It attracts the other ſemi-metals and metals, and unites with them all, except *cobalt* and *nickel*, with which it cannot by any means yet known be made to mix. This union is called an amalgamation [*d*]. This

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[*c*] The *ſpecific gravity* of Mercury is found ſo variouſly eſtimated by different authors, that there is ſcarcely any ground to judge what is the fitteſt to be followed. *See Note* [*b*] *to Sect.* 296. The Editor.

[*d*] 1. The Chemiſts of Dijon look on the amalgamations of mercury with other metals, as real ſolutions, which all depend on the mutual attraction between two or more ſubſtances, exerted in the *dry way*, and quite ſimilar to thoſe which take place in the *humid* or *moiſt way*; there being no other difference between both, than the form and the application of the crucible, or of the alembic, appropriated to contain the ſubſtances during the operation, according to the intenſity, or mildneſs of heat, and to collect the reſults, &c.

2. The great attraction that ſubſiſts between gold and mercury, has already been mentioned in Note [*l*] to p. 519. And it is from this great affinity, that the globules of Mercury loſe their ſphericity, if placed upon ſome metals, particularly gold, on which they ſpread themſelves, like water upon moiſt bodies, as the late ingenious chemiſt, Dr. Lewis, remarked in a note to Neumann's Chemiſtry, p. 133, of the 8vo edition, vol. I.

3. Mercury unites with gold, and alſo with ſilver; leſs eaſily with lead; ſtill leſs ſo with tin; very difficultly with copper; and moſt difficultly of all with iron, to which it ſeems to have inſuperable repugnance, as Newmann aſſerts. Dr. Lewis ſays, however, that quickſilver, in certain circumſtances, ſeems, in ſome ſmall degree, to act upon iron. That a plate of tough iron, kept immerſed in mercury for ſome days, became brittle. The ſame Author obſerved alſo, in his ſaid Notes, p. 101. that mercury adheres to, and coats the ends of iron peſtles, uſed in triturating certain amalgams of it with ſaline liquors;

This amalgamation, or mixtion of metallic bodies, according to the readineſs with which they unite or mix, is in the following progreſſion, viz. *gold*, *ſilver*, *lead*, *tin*, *zink*, *biſmuth*, *copper*, *iron*, and the *regulus of antimony*: But the three latter, however, do not very readily amalgamate. The iron requires a ſolution of the vitriol of iron, as a medium to promote the union.

f. It diſſolves in ſpirit of nitre, out of which it is precipitated by a volatile alcali, and common ſalt, in form of a *white powder*; but, if a fixed alcali is uſed, a yellow powder or calx is obtained [*e*]. *g*. But

liquors; and I found an iron wire, about one-tenth of an inch thick, very brittle, as if penetrated by the particles of the quickſilver, after I had ſtirred it, with that wire, whilſt boiling in the tubes of barometers, for ſetting looſe ſome bubbles of air that were ſticking to their inſide. *The Editor.*

4. It does not eaſily take up biſmuth, or regulus of antimony, unleſs they are previouſly mingled with other metals, or diſpoſed to unite with it by particular managements. Biſmuth, nevertheleſs, diſpoſes ſome other metals, particularly lead, to ſuch an intimate union with mercury, as to paſs along with it through the pores of leather.

5. If mercury is impregnated with one-*fourth*, one *eighth*, or even one-*twelfth* of biſmuth, it diſſolves maſſes of lead in a gentle warmth, without any agitation, or triture, comminution, or melting heat. Theſe laſt experiments were repeated with ſucceſs by Dr. Lewis. Boyle relates many curious preparations of mercury, by which it acquires very wonderful qualities, although ſome have been attempted by others, but without ſucceſs. *See* Neumann's Chemiſtry, *above quoted*; *p.* 136. *Vol. I.* and Note [*b*] to Sect 296.

[*e*] 1. Mercury is diſſolved with great rapidity by *nitrous acid*: the liquor is of a *greeniſh-blue colour*, but loſes it afterwards, and becomes limpid. This ſolution, when made with-

g. But it requires a boiling heat to diſſolve it

out heat, is uſed as a teſt for the analyſis of mineral waters, and has different properties from that made with the help of heat. In the firſt caſe, ſays Bergman, very little phlogiſton is loſt, and the ſalt eaſily cryſtallizes, being *white*, and ſcarcely acrid. It is not precipitated by diſtilled water: but, by cauſtic vegetable alkali, it is precipitated of a *yellowiſh* colour; by mild alkali, the precipitation is *white*; by mineral alkali, it is *yellow*, but it ſoon grows alſo *white*; by volatile alkali, it turns to a *greyiſh-black colour*; by Glauber's ſalt, or by pure vitriolic acid, the precipitation is *white*, *granulated*, and in a *ſmall quantity*; nor, if this precipitant has been ſparingly uſed, does this colour appear in leſs than an hour: by muriatic acid, or common ſalt, the precipitation is alſo *white*, but in a *large quantity*, and in *cuddles*.

2. But if the mercurial ſolution be put over a ſand-heat, it may be charged with a quantity of mercury, equal almoſt to its weight. According to the Chymiſts of Dijon, 10 ounces of nitrous acid may diſſolve 8 of mercury. The action of the ſolvent becomes ſtronger with the heat; emits great quantity of vapours: and if not taken from the fire, will be too far evaporated. Diſtilled water will precipitate from this ſolution a *white calx*, becauſe it is more dephlogiſticated, and the ſolvent is over charged with it; and the water changing the denſity of the liquor, diminiſhes the adheſion of the calx, as Fourcroy remarks. This *white* calx will turn *yellow*, if boiling water be poured on it. The vegetable alkali precipitates it of a *browniſh-yellow*, which, by degrees, aſſumes a *pale-yellow* tinge: the mild vegetable, and the mineral alkalies, produce nearly the ſame colour; though when this laſt is employed, the colour turns afterwards to *white*. The precipitation by volatil alkali is quite *white* alſo; that by the vitriolic acid is *yellow*; and finally, a copious *white mucilaginous matter* is the precipitate by the marine acid.

3. This ſolution by *nitrous acid* is very cauſtic; corrodes and deſtroys animal ſubſtances; when it falls on the ſkin, ſtains it of a deep *purple brown* colour, which appears *black*: the ſtains do not go off before the ſeparation of the epidermis, which

it in oil of vitriol [*f*].

h. It is not affected by the acid of common ſalt, unleſs it be previouſly diſſolved by other

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which falls away in ſcales, or kind of ſcars. It is uſed in ſurgery as a powerful eſcharotick, and is called *Mercurial water*.

4. The ſame ſolution, by cooling, is ſuſceptible of forming cryſtals, which vary from one another according to circumſtances: for the moſt part they are like needles; are very cauſtic; redden the ſkin; and detonate when put on burning coals, provided they be dry. They are called *Mercurial Nitre*, which fuſes, when heated in a crucible; exhales reddiſh fumes; aſſumes a deep *yellow colour*, which afterwards turns to *orange*, and at laſt to a brilliant *red*: in this ſtate is called *Red Precipitate*, or *Arcanum Corallinum*. It muſt be made in a matraſs with a gentle heat, if it is deſigned to be *corroſive* for Chirurgical purpoſes.

Mr. Bayen carried the detonation of *mercurial nitre* much farther. He diſcovered that 30 *grains* of this *ſubſtance*, when precipitated, either by the mild *volatil alkali*, or by *lime water*; or of *ſublimate corroſive*, when precipitated by *diſtilled water*, and properly dryed, being mixed with 4 *grains* of *flowers of ſulphur*, detonate in an iron ladle over the fire, with as great a report as that of a fowling-piece. See *Journal de Phyſique* for *May* 1779, *p.* 353. The Editor from *Bergman*, *Fourcroy*, *Neumann*, &c.

[*f*] The *vitriolic acid*, concentrated and boiling hot, ſeizes on mercury, and preſently reduces it, if urged by heat, to a kind of *white* powder (*ſee note* [*a*] *to* Sect. 288.), which turns *yellow* by the affuſion of hot water, but does not diſſolve in it; this is called *Turbith Mineral*; but if cold water, inſtead of being hot, was poured in the white maſs, the powder would not change its *white* colour into *yellow*, as was ſaid above about the nitrous ſolution.

2. This ſolution of Mercury by the vitriolic acid, is accompanied with a remarkable phenomenon; which is, that the acid contracts a ſtrong ſmell of *volatile ſpirit of ſulphur*, a notable proof that part of the phlogiſton of the Mercury had united therewith. *See the end of Note* [*a*] *to Sect.* 289.

other acids [g], in which caſe only they both unite with one another, and may be ſublimed together: this ſublimate is a ſtrong poiſon.

i. It unites with ſulphur by grinding, and then produces a black powder called *Æthiops*

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3. It deſerves notice, that though Mercury be more eaſily diſſolved by *nitrous* than by *vitriolic acid*; yet, if this laſt acid be put into a *nitrous ſolution* of mercury, the metal will quit the *nitrous*, in which it was diſſolved, and unite with the vitriolic acid.

4. If Mercury be rarefied by heat into vapours, and theſe meet with thoſe of *marine acid* in the ſame ſtate, a *corroſive ſublimate* will be formed.

This metallic ſalt ſhoots into cryſtals pointed like daggers, which are the ſtrongeſt of all poiſons. But there are various other proceſſes found in Chemical Authors, to make this ſalt with more or leſs trouble.

5. If *corroſive ſublimate* be mixed with tin, and diſtilled, a very ſmoaking liquor is produced, called by the name of its inventor, the *ſmoaking liquor of Libavius.*

The muriatic acid in the *ſublimate* is not ſaturated, and from hence proceeds its great corroſive power; for if a freſh quantity of mercury be added to it, and ſublimed a *ſecond* and *third* time, a *ſweet*, or mixed *ſublimate*, called *Mercurius Dulcis*, and *Aquila Alba*, is produced, which is not poiſonous, and is given internally as a *purgative*, or an *emetic*, according to the doſe.

This *Mercurius dulcis* may be rendered ſtill more gentle, by being ſublimed *nine times*: this being digeſted eight days with aromatic ſpirit of wine, and dried after the ſpirit is decanted, is called the *Panacea of Mercury.* The *Editor from Macquer's Elem. of Chemiſtry.*

[g] Muriatic acid does not act upon quickſilver, unleſs this laſt be previouſly deprived of as much phlogiſton, as $\frac{74}{100}$ of the quantity contained in the *hundred* of ſilver, or of $\frac{80}{182}$ in the *hundred* of zinc. *See Bergman's* Sciagraphia, *and his Treatiſe* De Phlogiſti quantitate. *The Editor.*

The

Æthiops mineralis [*b*], which ſublimes into a red ſtriated body, called *Factitious Cinnabar.*

k. The ſulphur is again ſeparated from the quickſilver, by adding iron or lime, to which the ſulphur attaches itſelf, leaving the quickſilver to be diſtilled over in a metallic form; but if a fixed alcali be uſed, ſome part of the quickſilver will remain diſſolved in the reſiduum, which is a *liver of ſulphur.*

[*b*] The Academicians of Dijon ſay, that the true proportion to make this æthiops, is that of *one* part of brimſtone with *four* of mercury. Fourcroy directs only 1 of *mercury*, with 3 of flowers of ſulphur, to be triturated, till the mercury is extinguiſhed. A black powder is then produced, which is the *æthiops mineral.* The combination is better effected, when the mercury is mixed with the fuſed ſulphur: by agitating this mixture, it becomes black, and eaſily takes fire: it ſhould be then taken from the fire, and the flame ſhould be extinguiſhed a little after, ſtirring the maſs till it becomes into ſolid clots. If this ſubſtance is expoſed to a great degree of heat, it takes fire, the ſulphur is conſumed, and a ſubſtance remains, which is of a violet colour when pulverized. This powder being put into matraſſes, till their bottom is red by the force of fire, is ſublimed after ſome hours, and artificial cinnabar is found in the top of the veſſels, cryſtallized into brown red needles.

Mercury divided, by means of a rapid and continual motion, as that of a mill-wheel, gradually changes itſelf into a very fine black powder, as already mentioned in Note [*a*], which is called *Æthiops per ſe*, on account of its colour, in order to diſtinguiſh it from this *Æthiops mineralis*, mentioned in the text. *The Editor from* Fourcroy, p. 446. *and* 479. *Engl. Edition*, Vol. I.

SECT.

SECT. 287. (217.)

Native Mercury.

A Quickſilver is found Native, or in a metallic ſtate. *Mercurius Nativus*, or *Virgineous* [*a*].

This is found in the quickſilver mines at Idria in Friuli, or the Lower Auſtria, in clay, or

[*a*] Mines of quickſilver are very rare in the earth. According to the calculation of Hoffman, there is *fifty* times more gold got every year out of the mines, than mercury and its ores. Dr. Lewis, in his notes to Newmann (p. 154. of Vol. I. 8vo edition), ſays that Cramer ſuſpects, that Hoffman only meant 5 times inſtead of 50; but neither the Latin nor the Engliſh edition of this Author expreſſes ſuch a thought; on the contrary, he adopts the ſame opinion; and only adds, that mercury is much more frequently met with than is commonly believed; but being ſo volatile in the fire, it often flies off in the roaſting of ores, and eſcapes the attention of Metallurgiſts.

2. The moſt conſiderable mines of Mercury are; 1ſt, thoſe of Idria in Friuli, and Carinthia, belonging to the Imperial hereditary dominions of Auſtria: 2dly, Thoſe of Spain at *Almaden*, near *Sierra Morena*, in the province of Eſtremadura: 3dly, Thoſe of the Spaniſh America, at *Guancavelica*, in the kingdom of Peru: 4thly, To theſe I may add thoſe of Braſil, near *Villa Rica*, between *Morro das Lages* and that of *Saint Anna*, where I am told by a native of that country, that ſuch a quantity of cinnabar and of native running quickſilver is found near the ſurface of the earth, that the black ſlaves often collect it in good quantities, which they ſell for a trifling price to the

or in a black-ſlaty lapis ollaris, out of which it runs, either ſpontaneouſly, or by being warmed even in the hands.

It

the apothecaries; but theſe mines never have been worked out; nor any notice taken of them by the owners. The ſame Braſilian told me beſides, that gold naturally amalgamated with mercury, was alſo found in the neighbourhood of that place; and, what is more extraordinary, he aſſerted, that almoſt all the gold mines of that country, are only worked out by ſimply waſhing them with running water, after reducing into powder the hard ores, which are ſometimes imbeded in quartzous and rocky matrices.

3. Neumann ſays, that the mines of Idria have produced at the rate of 231,778 pounds weight of mercury *per annum*; but thoſe of Almaden in Spain produce much more. The chemiſts of Dijon ſay, that their annual produce is about 5 or 6 *thouſand* quintals, or between 5 or 600,000 pounds weight. Only in the year 1717, there were more than *two millions* and 500 *thouſand* pounds weight, ſent from them to Mexico, for the amalgamation of the gold and ſilver ores of that country.

4. Bomare aſſerts, that the annual produce of the mines at *Guancavelica*, amounts to one *million pounds*, which are carried by land to Lima, thence to *Arica*, and finally to *Potoſi*, for the ſame purpoſe. The Imperial quickſilver, above-mentioned, is brought to Holland, and from thence to various other parts, the Dutch having entered into a contract with the Imperial government to be the purchaſers of the whole.

4. Beſides the *three* great mines of quickſilver, already mentioned in this Note and in the text, this metal is found likewiſe in various other parts of Europe; as thoſe at Muſchel-Landsberg, in the Dutchy of *Deux Ponts*, and in the *Lower Auſtria*. It flows there from a *ſhiſtoſe*, or *quartzoſe matrix*; and is probably mixt with ſome other metal, ſince its globules are not perfectly ſpherial, as Mr. Kirwan remarks. The mines of Friul are all in ſimilar beds or ſtrata. It is found likewiſe viſibly diffuſed through maſſes of clay, or very heavy

ſtone,

It has ſeveral times been found at Herr Sten's Bottn, in the mines of Salberg, in Weſtmanland,

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ſtone, of a *white*, *red*, or *blue colour*: of this kind are the mines of *Spain*, ſome of *Idria*, and of *Sicily*.

Maſcagni, already quoted in the Note to p. 266, found *fluid quickſilver*, as well as *red cinnabar*, and alſo *mineral æthiops*, near the lake of *Travale*, in the Dutchy of *Sienna*: the quantity however ſeems to be ſo ſmall, as not to deſerve working. On the contrary, the following mines produce clear profits enough to be worth the attention of the owners: *viz.* thoſe at *Kremnitz* in Hungary; at *Horowitz* in Bohemia; at *Zorge* in Saxony; at *Wolfſteim*, *Stahberg*, and *Moëſchfeld*, in the Palatinate. Mercury is brought alſo from Japan in the Eaſt Indies; but the greateſt part ſold in Europe, as *Japan cinnabar*, is manufactured in Holland, as Neumann aſſerts.

5. *Native* or *virgin mercury* was formerly ſought for by Alchymiſts with great anxiety and expence from Idria, for their great object of making artificial gold. Many others, nearly as mad, have been particularly fond of the Hungarian cinnabar, ſuppoſing it to be impregnated with gold: and ſo far has this ridiculous conceit prevailed, as Neumann ſays, that not only the mineral *cinnabar*, *antimony*, and *copper*, but the very *vine trees* of Hungary, have been imagined to participate of that precious metal. Even within theſe ten years, a ſingular French chymiſt announced to the public, that he had found a conſiderable quantity of gold in the aſhes of all *vine-twigs* and *ſtems*, and in the reſiduum of *garden ſoil*, after incineration. I was then at Bruxelles, and my good-natured friend, the late Mr. Needham, then at the head of the New Academy of Sciences, in that capital of Brabant, was highly diſpleaſed at my want of faith on ſo advantageous a diſcovery. But I was told afterwards, that the Count de Lauragais demonſtrated the fallacy and non-exiſtence of the fact, to the full ſatisfaction of the Royal Academy of Sciences at Paris.

5. Another alchymical whim, was that of fixing, or reducing mercury into a ſolid ſtate, ſo as to be employed like ſilver. But all proceſſes and operations of this kind, ſays Neumann,

land, and ſometimes alſo amalgamated with native ſilver. *See the next Section.*

SECT.

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if they have mercury in them, are no other than hard amalgams. When melted lead or tin are juſt becoming conſiſtent after fuſion, if a ſtick is thruſt into the metal, and the hole filled with quickſilver: as ſoon as the whole is cold, the mercury is found ſolid. According to Macquer, mercury expoſed to the fumes of lead becomes equally ſolid. And Maurice Hoffman, quoted by Neumann, gives a proceſs for reducing mercury, ſo coagulated, to a ſtate of malleability, by repeatedly melting and quenching it in linſeed-oil; ſo that a metal is thus obtained, which may be formed into *rings*, and other *utenſils*; but the caſe is, that the mercury is really diſſipated by the repeated fuſions, and nothing elſe is left, but the original lead or tin of this kind of amalgam: ſtill more ridiculous are thoſe, who, melting an amalgam of copper and mercury, with tutty, imagine the braſs that reſults, to be a production of the mercury; ſince this is diſſipated by the fire, whilſt the tutty, which is a kind of *cadmia fornacum*, and contains zinc, gives the yellow colour to the copper, as every one knows.

6. Wallerius, after mentioning the ſtrong ſoap leys, or cauſtic lexivium, and other methods for fixing mercury a ſolid ſtate, tells us very gravely, that, by means of a certain *gradatory water*, whoſe compoſition he affirms to have learned, with great labour, from the Treatiſe of Creuling *de Aureo Vellere*, he could make a coagulum of mercury whenever he pleaſed, of ſuch conſiſtency, that great part of it would ſuſtain cuppellation; but this pretended Adept has taken care not to diſcloſe to the reader, the proceſs to make that kind of miraculous water.

7. Lemery, Pomet, and others, lay down ſome external marks for diſtinguiſhing thoſe places, in which there are mines of quickſilver; namely, thick vapours like clouds, ariſing in the months of April and May, the plants being much larger and greener than in other places, the trees ſeldom bearing flowers or fruit, and more ſlowly putting forth their leaves, &c. But

thoſe

SECT. 288. (Additional.)

Quickſilver united to gold, or ſilver.

Hydrargyrum argento vel auro adunatum.

The ſtate in which mercury is found alloyed, or *amalgamed* with ſilver, according to the expreſſion uſed by Mineralogiſts, appeared to Sir Torbern Bergman to deſerve a particular place in the *Sect.* 217. of his *Sciagraphia.*

Our Author had already mentioned this combination at the end of the laſt Section: and Mr. Kirwan aſſerts, on the authorities of Monet and Lin. Von Gmelin, that in *Sweden* and *Germany* mercury has been found united to ſilver, in the form of a ſomewhat hard and brittle amalgam.

Romé de l'Iſle had a ſpecimen of this natural amalgam from Germany, which is imbedded in a quartzoſe maſs, and mixed with cinnabar, as Mr. Mongez aſſerts; and he adds, that in the *Royal cabinet*, at the *King's Garden at Paris*, is depoſited another fine ſpecimen of this mercu-

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These marks, ſays Neumann, are far from being certain. They are not obſerved in all places where there is quickſilver, and they are obſerved where there is none. In the Hartz-foreſt are ſeen abundance of thoſe cloudy exhalations, though not a grain of mercury is found there; to which may be added, that at Almaden in Spain, where ſo large quantities of quickſilver ores are found, no ſimilar indications are obſerved. *The Editor.*

rial

rial ore, which was found cryſtallized in the mine, called *Carolina*, at Muchel-lanſberg, in the Dutchy of *Deux Ponts*. The ſame Mr. de l'Iſle ſpeaks alſo very poſitively of a ſpecimen of *native gold* from Hungary, which ſeems to be a natural amalgam of *gold* and *mercury*. It is compoſed of quadrangular priſms, of a greyiſh yellow colour, and of a brittle texture. This ſpecimen is alſo in the *King's cabinet* at the *Royal Garden* at Paris. See his Note 344 and 345. p. 420. of the firſt volume of his *Criſtallographie*.

Mr. Kirwan, ſpeaking of the method of examining the purity of gold by the *moiſt way*, ſuppoſes, with Sir Torbern Bergman, that there are natural amalgamations of *mercury* with *gold* and *ſilver*: and Neumann obſerves (p. 154. of his firſt vol. in 8vo.), that ſometimes a mineral, containing gold or ſilver, is met with among mercurial ores, although this is a great rarity [*a*].

It is evident, therefore, from what has been ſaid in this Section, and to which may be added the amalgamation already mentioned in Note *a*,

[*a*] This obſervation, ſays Mr. Neumann (p. 155. of his firſt volume, 8vo.) ſeems to ſufficiently refute the opinion of thoſe who hold mercury to be an hypoſtatic principle, or ingredient in all metals. For if metals were, and continued to be, produced from mercury, we certainly ſhould, oftentimes at leaſt, diſcover one where the other is. Our Noble Author explains, in a very judicious manner, this old opinion of ancient Chymiſts. *See his* Sect. 220. (*the* 296 *of this edition.*)

e, N° 2, to the laſt Section, Note *f*, to p. 524, N°. 3. to p. 526; and alſo by the following Sect. 292. that there naturally exiſt various ores of quickſilver, amalgamated with *ſilver*, *gold*, and other minerals, although they be but ſeldom met with.

It is very probable, that the extraordinary great ſpecific gravity which is found in ſome ſpecimens of running quickſilver, proceeds often from its being naturally amalgamed with gold. According to Boerhaave, it may proceed alſo from its being rediſtilled a great number of times. By the ſame reaſoning we may ſuſpect, that the ſmalleſt of the ſpecific gravities of quickſilver proceed from its amalgamation with *ſilver*, *lead*, and other metals, and *ſemi-metals*, which, in ſpite of repeated diſtillations, may ſtill preſerve their union with it; and Boerhaave aſſerts, that after rediſtilling a great number of times the ſame amalgam of *quickſilver* with lead or tin, he never could perfectly free them, by this method, from one another. *See the laſt Article of his Second* Diſſertation on Mercury, p. 139.

That Mercury is many times found amalgamated with lead, is eaſily evinced, by the proceſs of Mr. Groſſe, related in the Memoirs of the French Academy, and mentioned by Mr. Macquer in his *Elements of Chemiſtry*, p. 296. Chap. 6. in 12mo. of the fifth Engliſh edit. where the method of extracting mercury from ſome ſolutions of lead is deſcribed; but the ſame Macquer, in his *Chemical Dictionary*, p. 205. Vol. III. in 12mo. poſitively affirms, that though Beecher and Kunchel have given other proceſſes for this extraction of mercury from lead: and although the method, indicated by Mr. Groſſe, be eaſier than the other proceſs; nevertheleſs it does not ſucceed, if the lead is quite pure, without any amalgamation with mercury. And Boerhaave has expreſly made the ſame aſſertion, complaining of thoſe Authors who affirm the contrary. See his Diſſertation *de Mercurio*, p. 133. at the end of the ſecond vol. of his Chemiſtry, of the Lat. edition 1732. *The Editor.*

SECT.

SECT. 289. (218.)

B. Mineralised, *Mercurius mineralisatus.*

1. With sulphur, *Mercurius sulphure mineralisatus.* Pure cinnabar, *Cinnabaris nativa* [*a*].

This

[*a*] Native cinnabar is of different shades, from yellowish to a deep red; and is found alone in hard, or in friable masses, either shapeless, or crystallized in *cubes*, and sometimes transparent. It is found also in very heavy *red*, or *brownish red* stones and sands; and intermixed with clay or stone, or interspersed through the ores of other metals, particularly those of *silver*, *copper*, or *martial pyrites*.

Its texture is either radiated, striated, scaly, or granular.

One *hundred* parts of cinnabar contain about 80 of *mercury* and 20 of *sulphur*; but artificial cinnabar contains a little more sulphur; and hence its colour is darker. *Kirwan.*

I have lately revived some quicksilver from native cinnabar, by mixing with it, after it was reduced into powder, an equal weight of iron filings, in a glass retort, and the loss amounted to nearly *twenty-one per centum*, whilst the artificial cinnabar revived in the same manner, lost 23,2 pounds in the *hundred*. The Editor.

It sublimes in close vessels; but is decomposed in open ones, and volatilized when sufficient heat is applied.

It is insoluble in *nitrous* acid, as Monet asserts, *p.* 313. of his Treatise on *Metallic Solutions*, edit. 1775.

Macquer says absolutely, that cinnabar is not attacked in the *humid way*, by any of the chemical solvents: the vitriolic acid, however, when urged by heat, may be said to calcine it, as will be mentioned hereafter.

Mineralogists reckon six varieties of cinnabar naturally found in the earth: 1. *Friable*, commonly called *flowers* of

This is of a red colour; and its ſpecific gravity to water is as 7500 to 1000.

a, Looſe or friable cinnabar, *Cinnabaris friabilis*, it looks like red ochre.

It is found in the Duchy of *Zweybruck* or *Deuxponts*, in Germany.

b. Indurated, *Minera Mercurii indurata*; ſolid cinnabar. Is of a deep red colour, and, with reſpect to its texture, is either,

1. Steel-grained, from *Siebenburgen*;
2. Radiated;
3. Compoſed of ſmall cubes, or ſcaly, from Idria and Hungary; or
4. Criſtalliſed,

a. In

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cinnabar, or *native vermillion*. It has the conſiſtence of a very fine powder, and ſometimes has a needle form appearance. It is found in *Idria*, in the Dutchy of *Deux Ponts*, at *Menidot* in *Normandy*: 2. *Striated*, in the form of *needles*, which are ſometimes diſpoſed into radiations from a common center. It is very brittle, and contains the greateſt quantity of quickſilver. It is found at *Almaden*, in the Dutchy of *Deux Ponts*, and in *Tranſylvania*: 3. *Lamellated*, or in the form of leaves: it only differs by its figure from the preceding, and is found with it: 4. *Granulated*, of a dark red colour, often of a compact and ſolid texture: ſometimes its colour is pale, like the peach-tree flowers. It is found at *Siebanburgen*, and at the above-named places: 5. the *Argillaceous* cinnabar, ſo called, on account of its mixture with clay, and fat earths; its form is lamellated, and is eaſily diſſolved in water, on account of the earthy mixtures. It is found at *Idria* and *Wolſtein*: 6. finally, the *Cryſtalized*, which is often tranſparent. *Monget*.

Profeſſor Brunnich, in particular, ſays alſo, in a Note to this Section, that ſome tranſparent pieces of cinnabar are found alſo in the mine near New-Mœrktel, in Carinthia.

The

a. In a cubical form; it is tranſparent, and deep red like a ruby, from Muſchlanſberg in Zweybruck.

The finer coloured cinnabrine ores are never worked for extracting the mercury, but employed as pigments; but they have been very injudiciouſly preferred to the more pure factitious cinnabar for medical uſes; as we ſeldom meet with any native cinnabar, that has not ſome mixture of earthy or ſtony matter, nor with two pieces that perfectly agree. In the ſhops three principal ſorts are diſtinguiſhed; *viz.* 1. in *maſſes* weighing from 1 to 6 and more ounces: 2. in *grains* prepared, by breaking the worſer maſſes, and picking out the beſt coloured bits: and 3. *waſhed cinnabar*, which is prepared by waſhing of the lighter impurities that are found in it.

No native cinnabar ſhould ever be employed internally as medicine, without being purified by ſublimation. I have never met with any native cinnabar, ſays Newmann, that did not leave on ſublimation a grey aſh or ſand, amounting, in different parcels, from one-*ninth* to one-*fifth* of the mineral employed: the reſiduum had no gold in it, although the colour of its ſolution and precipitate gave at the firſt ſight ſome expectation.

It is obſervable, ſays Newman, p. 157, of his firſt vol. in 8vo. that though vitriolic acid forms with mercury a lively yellow concrete, called *Turpeth Mineral*, and with the inflammable principle (the phlogiſtic ſubſtance) a *yellow* ſulphur: and although ſulphur itſelf forms with mercury a beautiful *red* cinnabar; yet the ſame vitriolic acid totally deſtroys this *red colour*, rendering it as *white* as milk. I repeated this curious proceſs juſt before I wrote this Note, and found that the *vitriolic acid* does not produce immediately the leaſt *change of colour* in common cinnabar; but being digeſted in a glaſs cup, over a ſtrong ſand heat, it ſoon turned as *white* as *cream*: and the vitriolic acid took the form of a ſtrong *ſulphureous* and *volatil* vapour, very ſuffocating and corroſive; emitting very piercing fumes for ſome time, which turned black the paper it was covered with, and deſtroyed its texture. *The Editor.*

SECT. 290. (Additional.)

Impure Cinnabars.

The three following mercurial ores deſerve to be treated of in a ſeparate place from the pure cinnabar of the preceding ſection.

1. A mercurial ore is found in Idria, ſays Gellert (p. 57. of Ed. 1776.), where the mercury lies in an earth or ſtone, as if it were in a dead form; and has the appearance of a red-brown iron-ſtone; but it is much heavier than that. It contains from 3 quarters to 7 eighths of the pureſt mercury; leaves, after diſtillation, a very black ſtrong earth behind, and gives ſome marks of cinnabar. This mineral, however, ſeems not, with that particular property as already mentioned, to be called an *ore*; but may rather be placed to the *native mercury*. For as we do not know the ultimate diviſibility of mercury, we cannot juſtly determine the point of its fluidity, although its globules may no more be diſcernible.

Theſe are the words of this great Metallurgiſt; and had he not ſaid, that this ore required a diſtillation to diſengage the metal, it might have been ranged among the native quickſilver ores. Such as it is, it deſerves to be noticed in this place. *The Editor.*

2. Liver

2. Liver ore, which is moſt common in Idria, and has its name from its colour. To all outward appearance it reſembles an indurated iron-clay; but its weight diſcovers that its contents are metallic. It yields ſometimes eighty pounds of quickſilver per hundred weight.
3. Burning ore. *Brand-erz* in German. This ore may be lighted at the candle; and yields from nine to fifty pounds of quickſilver *per* hundred weight. *Brunnich in his* aditions *to our Author's Mineralogy.*

SECT. 291. (Additional.)

Quickſilver mineralized with iron by ſulphur. Pyritous Cinnabar.

Sir Torbern Bergman inſerted this ore in the Sect. 177. of his *Sciagraphia*, and ſeems doubtfull whether this be a diſtinct ſpecies from the cinnabar; as the iron is perhaps, ſays he, only mechanically diffuſed therein. Mr. Monges remarks, that there are but a few inſtances of cinnabar in which iron is not found in its calcined form; though, in the act of the ore being reduced, it paſſes to its metallic ſtate, and becomes capable of being acted on by the load-ſtone. But if there are pyritous cinnabric ores, as there is not the leaſt doubt of their

exiſtence, they deſerve to be ranged, in a ſeparate ſection, by themſelves.

Another pyritous ore of cinnabar was found at *Menidot*, near *St. Lo* in *Lower Normandy*. It conſiſted in grains of different ſizes, of a red brown colour: they had a vitriolic taſte, and a ſulphureous ſmell.

Pyritous ores of this kind are found alſo at *Almaden* in *Spain*, and at *Stahlberg* in the *Palatinate*. The cinnabric pyrites of this laſt place are of a dodecaedral form. *The Editor from Bomare's* Mineralogie, *vol.* 2. *p.* 166.

SECT. 292. (Additional.)

Quickſilver mineralized with ſilver by the aerial acid, and ſulphur.

This ſeems to be a native precipitate *per ſe* or calx of mercury. It is ſaid to have been lately found in Idria, in hard compact maſſes of a browniſh-red colour, &c. Mr. Kirwan extracted a part only of this article from the *Journal de Phyſique* for January 1784, p. 61. I will, however, tranſcribe a fuller account of this article, as it ſeems to afford ſome further information.

This ore looks as a calciform maſs, of a ſolid and hard texture. It is of a brown-red colour on the outſide, but of a red colour in its fracture, which is granulated.

Various

Various little globules of mercury were contained in its pores, which are rendered viſible by being heated, but are ſoon re-abſorbed by cooling.

Expoſed in an iron-ſpoon to the fire, the red colour became more vivid; but by cooling, it turned yellowiſh.

Diſtilled in a pneumatic apparatus, a quantity of *dephlogiſticated* air was produced, though leſs by a fourth part than an equal bulk of common cinnabar ſhould produce; and about *ninty-one* parts *per centum* of running *quickſilver* were revived.

One ounce of this ore being diſtilled in a glaſs retort, a little *yellow powder* was left, which weighed ½ of a *grain*, and ſtained the bottom of the retort, as the calx of ſilver generally does on white glaſs in ſimilar circumſtances. This powder being ſuſpected to be a *calcined ſilver*, was cuppelated, with 144 grains of *lead*, after being wrapped up in a paper, in order to offer the phlogiſton of the burned paper to the later. After incandeſcence, the increaſed weight of the lead, over that of the teſt of compariſon, proved that the calx was reduced into its metallic ſtate of ſilver, and mixed with the lead.

If this account can be relied upon, it will prove, that quickſilver, even in a calciform ſtate, is naturally found mineralized with ſilver, by means of ſulphur. *The Editor.*

SECT. 293. (Additional)

Pyritous Mercurial Ores, with Silver and other Metals.

Mr. Monet, in his Sp. 77. relates, that he found in a metallic ore brought from *Dauphiné*, in 1768, by Mr. de Montigny, the following contents. This ore is of a *grey*, or *whitiſh* colour, and *friable*. On being analyzed, one *hundred* weight of this ore afforded $\frac{1}{100}$ part of *mercury* and 4 or 5 ounces of *ſilver*.

The remainder was *iron*, *cobalt*, *arſenic*, and *ſulphur*. *See his Mineralogy*, p. 392, *quoted by* Mr. Kirwan at *p.* 312, and *by* Mr. Mongez, §. 178. B.

Cinnabar, mixed with *arſenic*, or *realgar*, is ſaid to be found in *Japan*, according to Lin. Von Gmelin, quoted by Kirwan, *ibidem*, p. 312.

At Morsfeld *cinnabar*, and the white calx of *arſenic*, preſent themſelves in the ſame rock. Kirwan, *ibidem*.

SECT.

SECT. 294. (219.)

Quickſilver mineralized, with ſulphur and copper.

Mercurius cupro ſulphurato mineraliſatus.

This ore is blackiſh grey of a glaſſy texture, and brittle; crackles and ſplits exceſſively in the fire; and when the quickſilver and ſulphur are evaporated, the copper is diſcovered by its common opaque red colour in the glaſs of borax, which, when farther forced in the fire, or diluted, becomes green and tranſparent. It is found at Muſchlansberg in Zweybruck, or the Dutchy of *Deux Ponts* [*a*].

[*a*] It is ſaid, that there is alſo found in the ſulphur in Idria, a black cinnabar, that retains the colour in the ſublimation, which ſeems to indicate an abundant phlogiſton in the ſulphur; but this requires, however, a further confirmation. *The Author.*

Dr. J. R. Forſter ſays, *too boldly* on this matter, that the Author muſt have been miſinformed, as *no ſuch cinnabar* has *ever* been found; and adds, that a certain learned man thought he had likewiſe diſcovered ſome, near the copper ores at Lauterberg; but that it proved to be a red copper calx, which is ſtill found there ſometimes. *The Editor.*

SECT.

SECT. 295. (Additional.)

Quickſilver, mineralized by the marine and vitriolic acids.

Mineralogy owes the diſcovery of this ore to Mr. Woulfe, who publiſhed the account of it in the Phil. Tranſ. of London, for the year 1776. p. 618, and following.

It was found in the Dutchy of Deux Ponts, at the mine diſtinguiſhed by the name of *Obermoſchal.*

It had a *ſpar-like* appearance. This ore is either *Bright* and *white*, or *yellow* or *black.*

It was mixed with cinnabar in a ſtony matrix: and being well mixed with ½ of its weight of vegetable alkali, afforded cubic and octagonal cryſtals, that is, *ſalt* of Sylvius, and *vitriolated tartar.*

The marine ſalt of this mercury is in the ſtate of ſublimate corroſive. The Editor from Kirwan, p. 309.

SECT.

SECT. 296. (220.)

Observations on Quicksilver (*a*).

The divisibility of quicksilver in the cold might occasion some doubt, whether it really deserves

[*a*] 1. The Noble Author speaks in the beginning of this Section, about the great *divisibility* (or rather *fluidity*) of Mercury in the common temperature of our climates; because it was not known in his time, that this metal becomes *solid* and *malleable*, when exposed to the cold, indicated by the 40 degrees below *nought* in the scales of the two thermometers of *Fahrenheit*, and of *Celsius*, as has been already mentioned in Note [*a*] to Sect. 286. It has also been shewn, in the same Note, why Mercury, far from being reckoned as one of the semi-metals, deserves rather to be ranked among the *perfect metals*, on account of its essential properties, which were either unknown formerly, or not attended to.

2. But this metal possesses moreover some other singular qualities, and is applied to various useful purposes, as well philosophical as œconomical, part of which requires at least to be mentioned in this and in the next Note.

3. A notable property of quicksilver is, that of its being almost regularly *expanded* or *contracted*, in its bulk, according to the greater or less quantity of heat to which it is exposed, as Mr. De Luc and other philosophers have satisfactorily proved. It is on this account, as well as on that of its possessing a permanent form in all the common variations of the atmosphere, that mercury is the fittest of all known substances in nature, to indicate with nicety the degrees of *heat* and *cold*, at any time or place whatever, independently of any reference to our sensations, which are continually varying.

4. The relative quantity of this increase or variation of mercury in its bulk, has been ascertained by Sir G. Shuckburg, in the Phil. Trans. for 1777, p. 566. to be $\frac{10}{650,7}$ ($=\frac{1}{65,27}$; though, by error of the press, it is there marked $\frac{10}{637}$), from the

deſerves to be called a metal, if it had not a right

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the *freezing point* of ice (or from its *melting*, which is a more preciſe *point*) to that in which *water boils*. To this quantity, however, muſt be added $\frac{1}{400}$, on account of the expanſion of the tube in which the experiments were made; ſo that the whole increaſe of the bulk of mercury, by the variation of theſe two temperatures, amounts to $= \frac{1}{54,479}\left(\frac{63,07+400}{63,07\times 400} = \frac{463,07}{25228}\right)$ of its former bulk.

5. This quantity, however, being too ſmall to be eaſily perceived, rendered it neceſſary to make uſe of a proper contrivance to form that very uſeful inſtrument, called the *Thermometer*. This conſiſts in a hollow ball of glaſs, blown at the end of a narrow tube of the ſame ſubſtance, whoſe bore muſt be very ſmall and very even in its whole length. This being well filled with pure mercury, boiled, and hermetically ſealed, without leaving any air in the inſide, is expoſed to the heat of boiling water, when the barometer ſtands at 30 inches, the mean of its variations in our climates. The point anſwering to the upper ſurface of the incloſed mercury, is marked with a ſilk thread round the tube, and afterwards marked therein with a file; a ſimilar mark being taken alſo when the inſtrument is immerſed in thawing ice. The interval between theſe two marks is tranſpoſed upon a braſs ſcale annexed to the tube.

6. This ſpace, or interval, is divided into 180 equal parts, or *degrees*, according to the ſcale of Fahrenheit; or into 100 *degrees*, according to that of Celſius, uſed in Sweden: or into 80 *degrees*, according to that of Reaumur, uſed by the French. In the firſt Scale the number 212 is put on the mark of *boiling water*; 32 on the *freezing point*; and the 0° on the 32 diviſion below it. This is the moſt convenient of the three thermometrical ſcales, ſince all variations of heat, in common obſervations, are diſtinctly and ſimply announced; and are ſmall enough to render the uſe of fractions unneceſſary; but thoſe of *Reaumur* and *Celſius*, each of the firſt being equal to 2,25° of *Fahrenheit*, and each of *Celſius* to 1,8 of the ſame, require often to be ſubdivided, and to be diſtinguiſhed by the words *above* or *below nought*, to be underſtood without miſtake. Thus, for inſtance, 25 *degrees* of the Swediſh thermo-

right to it from the earlieſt times, being then reckoned

meter, *above* or *below* $= 25 \times 1,8 \pm 32 = 77$; or to 13 degrees of *Fahrenheit's* ſcale; and the ſame number of *degrees* of Reaumur's ſcale, are 25×2, $25 \pm 32 = 88\frac{1}{4}$, or to $24\frac{1}{4}$ of the ſame ſcale of *Fahrenheit*.

7. It was affirmed, in the beginning of this Note, that the expanſions of the bulk of quickſilver by heat, are nearly (for they are *not ſtrictly ſo*) in a regular arithmetical progreſſion, according to the quantity of heat it is expoſed to; and ſuch ſeems to be the caſe, according to the Table publiſhed by the ſame Mr. de Luc, at p. 309, of his firſt volume on the *Modifications of the Atmoſphere*. The following extract of this table ſhews theſe variations: and the firſt and ſecond differences are added, in order to render theſe irregularities more ſenſible. They are ſuch as can hardly be conceived from the nature of any ſubſtance, without the influence of extraneous and accidental cauſes, which may have eſcaped the attention of the obſerver; neither have they been found exactly true by Dr. Crawford. Mr. de Luc ſuppoſes the whole heat from the *melting ice* to that of *boiling water*, to be divided into 80 parts, by the fractional ſubdiviſions of which he expreſſes the abſolute quantities of heat, anſwering to each 5 or 10 degrees of Reaumur's thermometer ($= 22,5$ of Fahrenheit's ſcale); ſo that the whole ſum of theſe fractions amounts exactly to the aſſumed number 80; they are as follows:

Reaumur's Thermometer.	Fahrenheit's Thermometer.	Quantities of heat.	Firſt differences.	Second differences.
Degr. 80	212			
		9,44	,16	
70	189,5	9,60	,10	+,06
60	167	9,70	,16	−,06
50	144,5	9,86	,22	−,06
40	122	10,08	,12	+,10
30	99,5	10,20	,18	−,06
20	77	10,38	,36	−,18
10	54,5	10,74		
0	32			

8. Our Author obſerves (Sect. 286. [*b*] p. 578) that, although mercury is fluid, it is by no means *wet*; unleſs ſome water be intermixed in its ſubſtance. This laſt is a fact I have

chanced

reckoned among the metals, when even they were

chanced to ſee more than once, by the watery vapour that aroſe from boiling quickſilver, previouſly to fill therewith ſome barometers. But chemiſts, leſs accurate in their words, expreſs ſometimes the adheſion of this metal to ſilver and gold, ſaying, that it *wets them*, on account of the external appearance ariſing from the ſtrong attraction it has to both.

9. Though mercury does not act on earths; it unites and amalgamates with the greateſt part of metals. This is a kind of ſolution which makes no effervescence, becauſe no fixed air ariſes from theſe proceſſes; and if any loſs of phlogiſton happens in the conflict, it is neither very conſiderable, nor with ſuch a rapidity, as to render it ſelf-known to our ſenſes, as the Chemiſts of Dijon remark, Vol. III. p. 425.

10. The following articles relating to theſe amalgamations of mercury with other metals, are extracted from the ſame third volume of the Chemiſtry of Dijon, where the experiments of Mr. Sage of Paris are frequently quoted; and there is not the leaſt doubt, but they have been repeated and well aſcertained by the ſame Academicians.

11. The amalgam of gold and mercury, cryſtalliſes into quadrangular pyramids. Six ounces of mercury are retained by one of gold in this cryſtalliſation; but that with ſilver contains one-fourth more of quickſilver.

12. The ſtrong mutual attraction between mercury and gold or ſilver, is the ground of the method of ſeparating theſe metals, when they are native, from the earthy ſubſtances, that are naturally found mixed with in the mines; the ſmalleſt metallic particles forming an amalgam with it. Part of the mercury is ſtrained off, and the remainder is afterwards diſſipated by the heat of proper furnaces built for that purpoſe.

13. This amalgam ſerves alſo to cover pieces of copper and ſilver, with a golden ſurface, ſo that they appear as if intirely made of ſolid gold.

The pieces being well cleaned, are dipped in a feeble *aqua fortis*; afterwards in a nitrous ſolution of quickſilver, which covers their ſurface with a kind of ſilvering; and finally, the amalgam of gold is very equally ſpread over them: this being done,

done, the piece is expoſed to a proper heat to volatilize the mercury, which leaves the gold ſtrongly adhering to the metal, &c.

14. The amalgam with ſilver is alſo ſuſceptible of cryſtallization: It aſſumes a dendritical form: and every ounce of ſilver retains 8 of mercury. It is with this amalgam that is produced, by means of *nitrous acid*, well freed from the vitriolic by the *nitrous ſolution of ſilver*, that curious apparent vegetation, called *Arbor Dianæ*, or *Arbor Philoſophorum*. The following is the ſhorteſt proceſs.

Diſſolve 4 *groſs* (=228 *grains*=4×72) of ſilver, and 2 (=2×72 *gr.*) of quickſilver in *pure nitrous acid*; add to the ſolution, when made, 5 *ounces* (=5×576 *gr.*) of diſtilled water: put this ſolution into a ſpherical veſſel of white glaſs, at the bottom of which muſt already be put 6 *groſs* (6×72 *gr.*) of an amalgam of ſilver, of the conſiſtence of butter: let the veſſel be kept in a quiet place, free from any ſhaking or external agitation; and, at the end of ſome few hours, the figure of a buſh, or tree of ſilver, will be formed within the water of the glaſs veſſel. The metals contained in the ſolution, and in the amalgam, attract each other; and a number of ſmall tetrahedral cryſtals are formed, which lay hold at one another's end, and form the appearance of a vegetation, as I have ſeen in various cabinets of Natural Curioſities.

15. Quickſilver is alſo employed in Chili and Peru, to extract the native ſilver from its ores, by amalgamation, as has juſt been related, of thoſe of gold: the mercury is either ſeparated by diſtillation in large retorts of iron; or elſe the moſt fluid part is preſſed out, and the remainder is driven off by a diſtillation *per deſcenſum*, putting it in a kind of metallic ſieve over a veſſel of water, to receive the mercury, which is driven down by the fire lighted in a veſſel above the amalgam.

16. Copper amalgamates very difficultly with mercury, and only by mixing *blue vitriol* with mercury and water in an iron retort, over the fire. The acid attacks then the veſſel, and the copper is precipitated in a metallic ſtate, which, by ſtirring it hot with an iron ſpatula, unites to the mercury; but it ſhews no kind of cryſtallization.

17. Two ounces of melted lead being poured on a pound of mercury, produce a half fluid amalgam, which being decanted, gives ſome cryſtals like thoſe of ſilver. One ounce of theſe cryſtals retain one and a half of mercury. This amalgam

is

is advantageouſly employed to lute the glaſs veſſels, in which ſpecimens of Natural Hiſtory are to be preſerved in ſpirits of wine, as it has an admirable effect in preventing evaporation by the cloſe ſtoppage it makes.

18. The amalgam of quickſilver with tin, is advantageouſly employed in making looking-glaſſes, or mirrors. The thin ſheet of tin is laid down on a large flat table of ſtone: a proper quantity of mercury (in which ſome tin has been diſſolved, to avoid its deſtroying the tin ſheet) is rubbed over, with a lump of cloth like a flat bung, and the glaſs is carefully ſlided upon it from one end to the other, in ſuch a manner, that the dirty cruſt of the quickſilver is driven off before it's edge: the glaſs is then loaded with weights all over; by inclining gradually the ſtone-table, the ſuperfluous mercury is diſcharged; and in a few hours both cohere together.

19. The amalgam of tin is ſuſceptible of cryſtallization, which is in the form of thin ſhining *lamellæ*, with polygonous cavities between one another. Two ounces of tin retain 6 of mercury in this cryſtallization.

Quickſilver produces no amalgam with *iron* (See Note [*d*], N° 3. to p. 580.), nor with *regulus of antimony*. The firſt is the beſt intermedium to revive mercury from cinnabar: and antimony is alſo employed ſometimes for the ſame operation, though not with equal advantage. See the Note to p. 593.

20. The amalgam with biſmuth may be performed by heat: it produces regular cryſtals of an octaedral form, and lamellated triangles and hexagons; they are black on the upper ſurface, and ſhining underneath; two ounces of biſmuth retain double their weight of mercury in this cryſtallization.

21. When fuſed zinc is poured on mercury, a crackling noiſe is heard, that reſembles what is produced by a hot body when thrown into boiling water. This amalgam cryſtalliſes very well into lamellated hexagonal figures, leaving cavities among themſelves. One ounce of zinc retains two and a half of mercury in this cryſtallization.

22. Quickſilver does not amalgamate with *arſenic*, but by the force of heat, and this in a very ſmall quantity; nor does it amalgamate with *cobalt* nor with *nickle*.

Mr. Machy obſerved, that on the act of amalgamation, ſome cold is produced. He covered the ball of a thermometer with tin-foil, and putting it on mercury, the thermometer fell ſome degrees. This phenomenon thoroughly agrees with the new

new doctrine of Dr. Crawford on *Elementary Fire*; as a ſolid body requires a greater addition of heat to paſs from the ſolid to the fluid ſtate: ſo that the ſenſible heat of the thermometer muſt be diminiſhed, to unite to the tin-foil, with which it was covered, in the moment of becoming fluid.

23. This metal always feels cold, when touched, in the common temperature of the atmoſphere. Fourcroy ſays, that we are deceived in this caſe by our own ſenſations; for the thermometer being dipped in the ſame mercury, does not ſhow any lower degree of cold. The great continuity of contact between the live ſkin and the numerous metallic particles, in an equal ſpace, which are proportional to its great ſpecific gravity, neceſſarily produces a ſtronger ſenſation of its own temperature, this being always much leſs than that of a living body; and of courſe the multiplicity of theſe points of contact being all applied at once to this organ of our ſenſation, muſt be more powerfully felt, than whenever we touch any other matter that is lighter in itſelf, or of a much leſs denſity.

24. On the contrary, it is generally obſerved, that quick-ſilver, when expoſed to the ſame degree of *heat*, and in the ſame circumſtances, with various other bodies, becomes ſooner hot than any of them. The fundamental principle of this phænomenon conſiſts in the *ſmall quantity of ſpecific fire*, or in the *leſs capacity*, with which mercury is naturally endowed for receiving *heat*. This is ſuch, that, compared with the capacity of water for the ſame purpoſe, it is in the ratio of 0,033 to 100, as appears by the Table I have publiſhed of the *ſpecific fire* of various bodies, in my *Eſſay on Elementary Fire*. This Table was grounded upon various important experiments and obſervations made by Mr. Kirwan, in conſequence of the *New Theory on Fire*, diſcovered and publiſhed by Dr. Crawford. Hence it follows, that if equal quantities of *heat* be communicated to two equal quantities of *water* and *mercury*, this laſt will have a temperature *thirty times* greater than water; that is to ſay, in the inverſe ratio of their reſpective capacities, or as 1 to 30 (=0,033 : 1,000): in the ſame manner as it muſt happen, when equal meaſures of corn, or of any fluid, are thrown into veſſels, whoſe bottoms are as 30 to 1; for then the heights muſt neceſſarily be in their inverſe ratio, *viz.* of 1 to 30, &c.

25. Mercury, when rubbed between the fingers, emits a ſlight particular odour, as Mr. Fourcroy aſſerts. I have attempted this experiment many times, but without ſucceſs: perhaps on account of my imperfection, in the organ of this ſenſation.

The ſame Author aſſerts, that when mercury is pure, if agitated, it is obſerved to ſhine with a very ſenſible phoſphoric light, particularly in hot ſeaſons. This phænomenon has certainly been obſerved in the mercury of the barometer, by ſeveral philoſophers.; but I do not know whether it is generally ſo in other circumſtances: even in the barometer it does not take place, unleſs the Torricellian vacuum be not perfectly made in the ſpace at the top of the tube. Phials of glaſs are made on this principle, containing ſome quickſilver, and hermetically ſealed, which, on being ſhaken in the dark, produce light enough to ſee the hour on the dial of a watch. This luminous appearance is properly of the electric kind, and proceeds from the rubbing of the mercury againſt the ſides of the glaſs, in a very rarified medium. But if a *perfect vacuum* be produced, by nicely boiling the quickſilver within the glaſs, there will not be any electric illumination. This coincides with that curious phænomenon, diſcovered by Mr. Walſh, and repeated by Mr. Morgan, as deſcribed in the Philoſophical Tranſactions for 1786, p. 190. *viz.* that a perfect vacuum, or a ſpace quite void of any ſubſtance, is abſolutely impervious to the electric matter.

26. Quickſilver does not appear to diſſolve in water: but Fourcroy remarks, that Phyſicians are in the practice of ſuſpending a bag full of it in vermifuge ptiſans, during their ebullition; and that experience has evinced the good effects of this practice. Lemery aſſerts, that there is not any loſs of the weight of the mercury in this proceſs; if ſo, there may iſſue from this metal ſome *effluvium*, which is mingled with the water, though ſo volatile and ſubtle, as not to diminiſh, in a ſenſible manner, its weight. Others, however, aſſert, that the mercury loſes weight in this circumſtance.

27. Laſtly, mercury has not any taſte perceptible by the nerves of our palate; but it, however, produces very remarkable effects on the ſtomach and inteſtines of animals, as well as on the ſurface of the ſkin. Inſects and worms are infinitely more

more ſenſible than other animals of this effect: mercury kills them; and phyſicians employ it not only as a very excellent vermifuge, but as one of the moſt powerful remedies of the *Materia Medica* for many dreadful diſorders, beſides thoſe of the venereal kind, for which it is undoubtedly the moſt ſingular and effective ſpecific. But they are obliged to diſguiſe it, almoſt continually, under various forms and denominations, in compliance with the abſurd prejudices of the lower and illiberal part of mankind.

28, Even the moſt virulent product of mercury, known by the name of *Sublimate Corroſive*, already mentioned by the Author, p. 584. which is the moſt violent poiſon, is often taken internally in very minute doſes, under the direction of ſkilful phyſicians, and produces the moſt happy effects in a great variety of caſes, even of the moſt deſperate kind. This is a fact which I have experienced myſelf, in a dreadful ſcorbutic complaint I ſuffered for above four years, with reſtleſs and violent pains of the eyes and head. None of the moſt able phyſicians in London and Paris I conſulted, afforded me any effectual relief, till I had the good fortune to conſult Mr. Sacré, ſurgeon oculiſt at Antwerp. His preſcription conſiſted of three grains of *ſublimate* diſſolved in a pint of *common proof ſpirit*, called of *wine*, though it is, and ought to be, of corn (*frumenti*), or malt ſpirit; the doſe conſiſted in taking every morning two ſpoonfuls of it, in a pint of new milk. In leſs than two weeks, I began to feel relief; and in three months time, I was completely cured. The firſt methodical practice of this remedy, was communicated to the famous Van Swieten, firſt Phyſician to the Emperor's Court, by my late worthy and very much regretted friend Dr. A. R. Sanches, then Archiater, or Chief Phyſician to the Court of Petersburg, as it appears by the laſt volume of the Commentaries of the ſame Van Swieten, p. 550. of the Leyden edition, in 4to, 1772. This volume was publiſhed after the Author's death; but he had enjoyed, during his life, the glory of being the author of this wonderful remedy, which continues to bear his name among the ignorant and inaccurate phyſicians of our times. *The Editor.*

were named after the metals, the number of both being thought equal (*b*).

[*b*] 1. The great *ſpecific gravity* of quickſilver, being in fact the neareſt to that of *gold*, and greater than that of any other metal, *platina* only excepted, ſufficiently ſhews, that this metal could not be ranged with propriety among the ſemi-metals. This gravity is, however, very differently appreciated by various Authors. Bergman, in his *Sciagraphia*, ſtates it to be =14,110: and Muſſchenbroek aſſerts, that ſuch was the *ſpecific gravity* of the quickſilver that had been ſublimed 511 times. This, in all probability, was the ſame of which Boerhaave ſpeaks in his firſt Diſſertation *de Mercurio*, p. 134. printed at the end of the ſecond volume of his *Elementa Chemiæ*, Leyden, 1732. But ſome other authors, among whom is Mr. Fourcroy, reckon this ſpecific gravity to be no more than 13,000. Modern experiments ſhow, however, that it generally lays between both, *viz.* about 13,600, or 13.500. This, I am informed, was the mean *ſpecific gravity*, found by the late Lord Cavendiſh, after the repeated and nice tryals he made upon 50 different ſpecimens of quickſilver, on which he employed all his induſtry and attention, to determine this point.

2. The hydroſtatical experiments I lately undertook of this kind, upon 10 different ſpecimens of mercury, two of which were revived from *native* and *artificial* cinnabar, by the operator of Mr. Kirwan, confirmed me in the ſame opinion. The temperature of the atmoſphere was nearly the mean, *viz.* at the 50th *degree* of Fahrenheit's thermometer; and the ſcales employed in theſe operations were ſo nice, that they turned with $\frac{1}{10}$ of a grain, when loaded with 4 pounds weight.

The method employed, in aſcertaining theſe *ſpecific gravities*, is the eaſieſt of all, and I thought it new, till I afterwards found it had been mentioned by Meſſieurs Luyart, on their Treatiſe of the *Analyſis of Wolfram*. It is as follows:

3. A phial of white glaſs, with a ground ſtopple, was counterbalanced with lead, or other matter, in a nice pair of ſcales. The ſubſtance to be tried, was introduced into the phial, and weighed together (ſuppoſe = *a*). The remaining

ſpace

The opinion, which has a long time prevailed, that the quickſilver is a neceſſary ingredient, and conſtituent part in all metals, is not ſo

ſpace of the phial being then filled with diſtilled water, it was again weighed (ſuppoſe $=b$).

N. B. Particular care was taken, that no bubble of air remained in the inſide. For this purpoſe a very ſmall grove was made, with a file, on the ſide of the ground ſtopple: this was introduced ſideways, without admitting any air, leaving room to the ſuperfluous water to ruſh out. Laſtly, the phial was emptied, and cleaned; and, being filled with the ſame kind of water, was alſo weighed (ſuppoſe $=c$).

It is evident, that $b-a=d$ the quantity of water in the ſecond operation: $c-d=e$ the water equal to the bulk of the ſubſtance; and that $\frac{a}{e}$ is the real *ſpecific gravity* ſought for.

4. The greateſt ſpecific gravity I found among theſe 10 ſpecimens of mercury, was $=13,620$; and the ſmalleſt was $=13,450$. The *heavieſt*, was neither of the two that had been diſtilled from cinnabar; but a common quickſilver I had bought at Apothecaries Hall, in London; and the *lighteſt* was taken from a barometer of the beſt and dearer kind, made by one of our moſt reputed inſtrument-makers in England.

5. Various may be the cauſes, which produce the great differences, that are obſerved ſometimes in the ſpecific gravity of mercury. The moſt obvious ſeems to be its mixture, or amalgamation with other metals. Certainly, when united to *gold*, its gravity muſt of courſe be ſpecifically augmented; on the contrary it muſt be leſſened, when amalgamated with any other metal, *platina* only excepted: and the ſame muſt be the event, whenever water, or moiſture, is found mixed with mercury (N° 9. of this ſame note to p. 615.); for in ſuch a caſe it will be found heavier after evaporation. A ſimple boiling of the quickſilver, for ſome time over the fire, in an open veſſel, will compleatly free it from this mixture; and no careful maker of experiments ſhould ever neglect this preparation, before he undertakes to employ mercury in any proceſs, or purpoſe of the philoſophical kind.

ſo generally received now as heretofore; ſince thoſe proceſſes, which have been advanced as proofs of it, and which have however but ſeldom

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6. I have hinted already, upon good authority (Note *a*. N° 2. to Sect. 286.) that mercury becomes not only purer, but *heavier*, after it has undergone very numerous ſublimations.

The aſſertion of Boerhaave, in his diſſertation already quoted (N°. 1. of this note), where he ſays to have examined the *ſpecific gravity* of the mercury diſtilled 511 times, *per inſtrumenta irreprehenſa et prudentiſſima ſolicitudine*, commanded my belief: but *quandoque bonus dormitat Homerus*; as I found, ſince the laſt ſheet was printed, that the ſame reſpectable philoſopher has expoſed his doubts on the exactneſs of that operation, in a ſecond Memoir, he ſent, three years after the former, to the ſame Royal Society of London, which was inſerted in the *Philoſ. Tranſactions* for 1736, p. 374; where he candidly acknowledges, that having continued to diſtill that quickſilver till 877 times, its ſpecific gravity, ſhown by the nice hydroſtatic balance of the ingenious Mr. 'sGraveſande, appeared to be no more than 13,500, to that of diſtilled water.

7. Boerhaave died two years after (on the 23d of September 1738); and left his papers to his two nephews, Herman (who died the 7th of October 1753), and Kaw (deceaſed 5 years after, *viz.* the 6th of July 1758): after their deaths, theſe manuſcripts fell into the hands of Charles Frederick Kruſe, Phyſician to the Emperor of Ruſſia. This gentleman publiſhed a ſhort extract from Boerhaave's Diary, in the 9th vol. of the *Novi commentarii* of the Imp. Acad. of Peterſburg, p. 396. The following are the reſults of this printed extract, which the reader may perhaps be pleaſed to find in this place.

The ſpecific gravity of the pureſt gold, to diſtilled water is	19,024
That of mercury, diſtilled once in a glaſs retort	13,570
Diſtilled 1009 times	13,590

dom been repeated, do by no means ſucceed, at leaſt not in all places.

It is rather ſuppoſed, that by the mercurial earth the ancients muſt have underſtood an earth,

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Diſtilled once from its amalgam with gold	13,550
Diſtilled 750 times from the ſame amalgam	13,520
Diſtilled 877 times from the ſame	13,500
Diſtilled once from its amalgam with ſilver	13,550
Diſtilled 217 times, from the ſame amalgam, with ſilver	13,500

8. It is evident, therefore, by theſe facts, that mercury does not acquire any additional increaſe to its *ſpecific gravity*, by the mere repetition of its ſimple diſtillations, nor by its amalgamations with gold or ſilver, provided it be afterwards properly ſeparated by fire.

9. In the ſame manner, when water, or moiſture, is found mixed, with mercury, as has been mentioned, N° 5. of this Note, if the moiſture comes to be evaporated, the mercury will remain heavier than before. This proceſs is very eaſily performed, it only requiring the mercury to be boiled for 20 or 30 minutes, in an open veſſel over the fire; as was already mentioned in the ſame place.

10. There remains ſtill another cauſe, from which ſome varieties may ariſe in aſcertaining the ſpecific gravity of quickſilver, as well as of other ſubſtances. This is the difference of the temperature of the atmoſphere at the time of making the operation. This has been a very material circumſtance, which was forgotten or unattended to, by almoſt all the authors, who have laboured hard to form large tables of the *ſpecific gravities* of numerous ſubſtances. Unhappily! for want of this eſſential circumſtance, their labours cannot produce any good effect; and, if not intirely uſeleſs, they cannot afford a proper ſatisfaction in the nice inquiries that depend on this kind of knowledge. The celebrated Chriſtian Wolfius, in his *Elements of Hydroſtatics*, Vol. II. p. 263, gives an abſtract of Eiſenchmid's table of *ſpecific gravities*, where it is aſſerted, that a cubic inch of mercury weighs, in ſummer, 7 *oz.*

which may, by addition of phogiſton, be reduced in the fire to a metallic ſtate; and this appears to be ſo much the more reaſonable, as

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1 *groſ.* 66 *gr.*; but in the winter it weighs 20 *gr.* more; *viz.* 7 *oz.* 2 *groſ.* 14 *gr.* This, however, leaves the whole nearly in the ſame uncertainty; ſince the *mean temperature* between ſummer and winter is widely different in various climates, and in various local ſituations; nor is it often the ſame in every year at each place. So that, unleſs every time, that the *ſpecific gravity* of mercury, or of any other ſubſtance, is taken, the degree of ſome known and comparable thermometer, ſuch as thoſe of *Fahrenheit*, *Celſius*, or *Reaumur*, be declared, to aſcertain the real temperature in which the operation was performed; there cannot be a poſſibility of forming an adequate idea of the reſults.

11. Before I diſmiſs the ſubject, I muſt beg leave to give a ſpecimen, or two, of the enormous blunders committed by various philoſophers and numerous pretenders, who have been extremely buſy in our times, to determine the heights of mountains, and the relative poſition of places above the level of the ſea; by means of barometrical obſervations, without paying any particular attention to the *ſpecific gravity* of the mercury, with which their barometers were made. If the two barometers were both at 30 inches high, and equally circumſtanced in every other reſpect, excepting only their *Specific gravity* of the quickſilver; ſo that one be filled with the firſt kind I have tried, *viz.* whoſe ſpecific gravity was = 13,62 and the other = 13,45.

In this caſe, and in all probability many of this kind have often occurred, the error muſt have been no leſs than 327 feet; becauſe the heights of the mercurial columns in each barometer muſt be in the inverſe ratio of their ſpecific gravities: *viz.* 13,45 : 13,62 :: 30 : 30,379.

Now the logarithm of 30 = 4771.21
ditto of 30,379 = 4825.73

the difference is = 54.52

which difference ſhows, that there are 54.52 *fathoms* between one place and another, or 327, *feet*; though in reality both places are on the ſame level.

12. But

the quickſilver does not attract the metals when in the form of calces.

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12. But if the ſpecific gravity of the mercury, in the two barometers, were as the two above mentioned by Bergman and Fourcroy; viz. one of 14,110, and the other of 13,000, which may happen to be the caſe, as the heavieſt is commonly reputed the pureſt mercury; on this ſuppoſition the error muſt have amounted to 35,576 toiſes, or above 2134, feet and a half; becauſe 13,000 : 14,110 :: 30 : 32,561

Now the logarithm of 30 = 4771,21

and that of 32,561 = 5126,97

the difference is = 355,76; which ſhews that the error ſhould amount to ſo many *fathoms*; or 2134,5 *feet*. *The Editor.*

ORDER

ORDER THE SECOND.

Imperfect, or Baſe Metals.

SECT. 297. (180.)

Tin. *Stannum, Jupiter,* Lat. *Zinn,* Germ. *Etain,* Fr.

Its Properties.

Tin is diſtinguiſhed from the other metals by its following characters and qualities. It is

a. Of a white colour, which verges more to the blue than that of ſilver.

b. It is the moſt fuſible of all metals [*a*]; and, The

[*a*] Tin melts in the fire before it grows red hot, and much eaſier than any metal, except quickſilver, *viz.* at the 415 *degree* of Fahrenheit's thermometer according to *Bergman.* Dr. Lewis ſays, that this degree is the 430; but, according to Nicholſon, the 410 degree is a ſufficient heat to produce the ſame effect. It would be an acceptable preſent to curious Metallurgiſts, if ſome nice experimenter ſhould undertake to enlarge the table given in the Note to page 230; and aſcertain the melting heat of all other metals, that are

c. The leaſt ductile; that is, it cannot be extended or hammered [*b*] out ſo much as the others.

d. In breaking or bending it makes a crackling noiſe [*c*].

It

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are not mentioned in that table; by means of Wedgwood's new thermometer, which may be eaſily purchaſed at the inventor's ware-houſe, in *Greek-Street* Soho-Square. When tin is heated till almoſt ready to melt, proves extremely brittle: large blocks of it are, in this ſtate, beaten into pieces from a blow of a hammer. The purer ſort, from the facility of its breaking into long ſhining pieces, is called *Grain Tin.* When melted, if nimbly agitated at the inſtant of its beginning to congeal, is reduced into ſmall grains or powder. *The Editor.*

[*b*] Tin is ſo ductile as to be beaten into very thin leaves. But *ductility*, and *extenſibility*, are two different properties, leſs connected with one another than is generally imagined. Iron and ſteel are drawn into exquiſite fine wire, but cannot be beat into very thin leaves. Tin, on the other hand, is beat into fine leaves, and may be extended between rolers to a conſiderable ſurface. The tin ſheet uſed in various arts, is commonly about $\frac{1}{280}$ part of an inch; but may be extended twice as much in its dimenſions, without difficulty. Notwithſtanding this extenſibility, tin cannot be drawn into wire, on account of the weak cohesion of its particles. A tin wire, however, of one-tenth of an inch diameter, is able to ſupport a weight of 49 ½ pounds, according to Fourcroy. Gold and Silver poſſeſs both properties of ductility and extenſibility, the moſt eminently of all metallic bodies; whilſt lead, notwithſtanding its flexibility and ſoftneſs, cannot be made either into leaves or wire or any fineneſs. *Editor, chiefly from* Lewis.

[*c*] This crackling noiſe, which is commonly ſuppoſed to be an eſſential property of pure tin, moſt probably belongs only to ſuch tin as contains arſenic; for thoſe operations, by which this noxious ſemi-metal is ſeparated from tin, deprive it of that noiſe.

Henckel

Henckel diſcovered a method of ſeparating actual arſenic from tin; namely, by ſlowly diſſolving tin in 8 times its quantity of *aqua regia* made with ſal-ammoniac, and ſetting the ſolution to evaporate in a gentle warmth. The arſenic begins to concrete whilſt the liquor continues hot, and more plentifully on its growing cold, into white cryſtals. *Lewis.*

Marggraf has given a more particular account of this proceſs in the Memoirs of Berlin for 1747. He obſerves, that the white ſediment, which at firſt ſeparates during the diſſolution, is chiefly arſenical. That the tin of Malacca, though accounted one of the pureſt ſorts, yield no leſs than one-fourth of its weight of arſenical cryſtals. That ſome ſorts yield more: but that tin, extracted from any particular ore, which does not hold arſenic, affords none; ſo that this poiſonous ſubſtance is but accidentally united to tin. Arſenic may be alſo ſeparated from tin by means of mercury; for an amalgam of tin being long triturated with water, and the powder, which was waſhed off, committed to ſublimation, a little mercury comes over, and bright arſenical flowers ariſe in the neck of the retort.

It was in conſequence of Henckel and Marggraf's aſſertions, that the *Lieutenant General* of the Police at Paris gave it in commiſſion to the College of Pharmacy in the year 1781, as Watſon relates (Vol. IV. p. 153), to make all the neceſſary experiments for determining whether pure tin might, or not, be uſed for domeſtic purpoſes, without danger to health? In conſequence of this commiſſion, Meſſieurs Charland and Bayen publiſhed their reſearches, by which it appears, that neither the *Eaſt India*, nor the *pureſt* ſort of *Engliſh* tin contained any arſenic, though the *Engliſh tin* uſually met with in commerce, though not really Engliſh (See N° 3. of Note [*a*] Sect. 304.) did contain ſo ſmall a portion of arſenic, that it not amounted at moſt to *one grain per ounce*, viz. $\frac{1}{576}$ of it's whole weight: and that ſuch ſmall portions of tin, as may be mixed with our food, from being prepared in tin veſſels, can by no means become dangerous, or at all ſenſible in the animal œconomy. The large quantities of tin, which are ſometimes given internally in medicine with perfect ſafety, and the conſtant uſe our anceſtors made of tin veſſels, before the introduction of china and other earthen wares, render all other proofs of the innocent nature

of

e. It has a ſmell particular to itſelf, and which cannot be deſcribed [*d*].

f. In the fire it is eaſily calcined to white aſhes, which are twenty-five per cent. heavier than the metal itſelf. During this operation, the phlogiſton is ſeen to burn off, in form of ſmall ſparkles, among the aſhes,, or calx [*e*].

g. This calx is very refractory; but may, however, with a very ſtrong degree of heat, be brought to a glaſs of the colour of hard

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of tin quite ſuperfluous. *The Editor chiefly from* Lewis, Fourcroy, &c.

[*d*] When friction or heat is employed, the ſmell of tin becomes more remarkable.

It has alſo a diſagreeable taſte peculiar to itſelf, ſo very ſtrong, that ſeveral phyſicians have aſcribed to it a very perceptible action upon the animal œconomy; and have therefore recommended it in ſome diſeaſes. *The Editor from* Fourcroy *and* Mongez.

[*e*] Tin by calcination contracts a browniſh grey powder on its ſurface, which on raiſing the fire to a cherry red, ſwells, burſts, and diſcharges a ſmall bright white flame of an arſenical ſmell. The metal, when juſt calcined, appears of a duſky greyiſh or aſh colour; by a long continuance of the fire, becomes white, the more ſo in proportion as the tin was purer.

Though tin itſelf is ſo eaſily fuſed, its calx is extremely refractory. Even in the focus of a large burning lens, or of a concave mirror, it only ſoftens a little, and forms cryſtalline filaments. With glaſs of biſmuth, or with the ſimple, or the arſenicated glaſſes of lead, the moſt powerful fluxes known for refractory calces, it does not perfectly vitrify, forming only opake milky compounds: By this property it is fitted for making the baſis of the imperfect glaſſes, called Enamels. *Editor from* Lewis.

roſin,

roſin, or *Colophony*. But this calx is eaſily mixed in glaſs compoſitions, and makes with them the *white enamel*.

h. It unites with all metals and ſemi-metals; but renders moſt of them very brittle, except lead, biſmuth, and zink [*f*].

i. It amalgamates eaſily with quickſilver. *See* the Note n° 18 to *page* 608.

[*f*] Notwithſtanding that tin of itſelf is ſo ſoft and ſo unſonorous, it ſurprizingly improves the ſonorouſneſs, and deſtroys the ductility, of ſome of the other metals, particularly gold, ſilver, copper, and braſs. Bell-metal, the moſt ſonorous of all metallic bodies, is a compoſition of copper and tin. The minuteſt portion, even the vapour of tin, renders many ounces, and even pounds of gold or ſilver, ſo brittle, as to fall into pieces under the hammer. The leaſt particle of tin, falling on the ſtones or luting of a furnace, will make all the gold and ſilver melted in it, hard and brittle. On this account Tin is called, by metallurgiſts, the *Diabolus Metallorum*. Thus far is the aſſertion of Neumann, p. 125 and 126. Vol. I. of his *Chemical Works*. See alſo note [*i*] to p. 519.

But it appears, by the experiments of Mr. Alchorne, Aſſay Maſter of the London-Mint, that gold, with $\frac{1}{720}$, and even with $\frac{1}{1440}$ of tin, does not become brittle. *See* Phil. Tranſact. *for* 1784, *p*. 464.

Tin, the moſt fuſible, and iron, the moſt refractory of all the metals, unite eaſily with one another, and ſeem to have a great affinity. Iron diſſolves by melted tin, in a heat far leſs than that in which iron by itſelf melts. The compound is white and brittle. Iron, added to a mixture of lead and tin in fuſion, takes up the tin, leaving the lead at the bottom; and, in like manner, if lead, tin, and ſilver, are melted together, the addition of iron will abſorb all the tin, and the tin only. Hence we are furniſhed with a method of purifying ſilver from tin, and conſequently of preventing the inconveniencies, which this metal occaſions in the refining of ſilver by cupellation with lead. *The Editor, chiefly from* Neumann *and* Lewis.

k. It

k. It diſſolves in aqua regia, the ſpirit of ſea-ſalt, and the vitriolic acid; but it is only corroded into a white powder by the ſpirit of nitre [*g*].

[*g*] Nitrous acid acts very powerfully on tin. To obtain a perfect ſolution, the metal muſt be added a very little at a time, and all heat avoided. If much tin be put at once, the corroſion takes place with great rapidity and heat; and the metal is deprived ſo much of its phlogiſton, that it falls to the bottom in the form of a white calx, inſoluble in acids, and of difficult reduction: Macquer acknowledges, that he could never ſucceed in the attempt. This calx is advantageouſly employed in making the white enamel. According to Bayen and Charlard, quoted by Fourcroy, from the ſolution of tin with nitrous acid to ſaturation (ſo that the acid be thick and incapable of acting on a new addition of the metal) by waſhing this maſs in a great quantity of diſtilled water, and evaporating this ley to dryneſs, a ſalt *ſtanno-nitroſus* is got, which detonates alone in a well-heated pot: and burns with a thick white flame, like that of phoſphorus. Aqua Regia, made of two parts of nitrous, and one of marine acid, combines with tin; and makes a ſtrong effervescence. The metal muſt be put in the ſolvent, only little by little; or elſe a great part will be calcined. The aqua regia may in that manner be impregnated with half its weight of tin. This ſolution of tin exalts the tincture of *cochineal*, of *gum-lac*, &c. turning the colour to that of ſtrong fire-red; which is employed by dyers to give the ſcarlet colour to cloth. It ſerves alſo to precipitate the gold from its ſolution, into a fine purple coloured calx, called *the Powder of Caſſius*, its inventor, which ſerves to give that colour to glaſs and enamel (See p. 530).

The muriatic or marine acid diſſolves tin by means of heat: if it be granulated, and put into a matraſs over the fire, a ſmall effervefrence is produced; when ſaturated, above half the weight of the tin is found diſſolved, and fine cryſtals may be produced from the ſolution, by the uſual proceſs in ſimilar caſes.

The

The vegetable acid, ſoaps, and pure alcaline ſalts, alſo corrode this metal by degrees.

Of all the acids, the marine acid has the greater affinity with tin; but does not diſſolve it without heat. It forſakes ſilver, mercury, and antimony, to unite with tin. When thus combined, it volatiſes a conſiderable part of the metal: and a ſtrong ſmoking ſpirit comes over, which, if diluted with water, grows milky, and depoſits the tin. This ſpirit is known by the name of *Fuming Liquor of Libavius*, and is a pure marine acid *charged*, but not *ſaturated* with tin.

An amalgam of four parts of *tin*, with five of *mercury*, being well triturated in a glaſs mortar, with an equal weight of corroſive ſublimate, the whole is put in a glaſs-retort, and expoſed to a reverbatory furnace, having luted to it a large receiver, with a little hole on the top to give vent, when neceſſary, to the elaſtic vapours. The diſtillation muſt be begun with a gentle heat. At firſt a colourleſs liquor paſſes over, and a white thick vapour riſes, which emits white and copious fumes. This liquor, contained in a phial, diſcovers no ſigns of vapour; a certain quantity, however, is diſengaged, which depoſits the calx of tin in needle-like cryſtals upon the upper part of the phial; and a ſmall quantity of calx is alſo precipitated at the bottom, in the form of irregular leaves. It has a very penetrating ſmell, which excites coughing. This gas of the liquor has but a ſmall degree of elaſticity. The reſiduum, after diſtillation, preſents an amalgam of mercury and tin; and above it a kind of butter of tin, or *ſtannum corneum*, which may be volatiliſed by the force of heat.

Vitriolic acid, according to Neumann, requires to be highly concentrated, and aſſiſted by a boiling heat, in order to diſſolve tin. The inflammable principle of the metal, extricated during the ſolution, unites with a part of the acid into a true ſulphur, which ſublimes, in its proper form, into the neck of the retort; and a vitriolic acid air eſcapes during the ſolution. *See Note* [a] *to p.* 491. *concerning the formation of* Sulphur. *The Editor chiefly from* Macquer and Fourcroy.

l. Its

l. Its ſpecific gravity is to water as 7400 to 1000, or as 7321 to 1000 [*b*].

m. Diſſolved in aqua regia, which for this purpoſe ought to conſiſt of equal parts of the ſpirit of nitre and ſea-ſalt, it heightens the colour of the cochineal, and makes it deeper; for otherwiſe that dye would incline to violet.

[*b*] The lighteſt tin is the pureſt. According to Bergman its ſpecific gravity is=7264. According to Cotes, Ferguſon, and Emerſon, it is=7320. According to Boerhaave=7321; according to Muſſchenbroek and Wallerius=7471; and, according to Martin it is=7550. But Watſon ſays, that none of the authors he quotes, in eſtimating the ſpecific gravity of tin, had uſed the pureſt ſort, but rather a mixture of it with lead: and gives the following table of the weights of various mixtures of tin with lead, by which the *ſpecific gravities* are at the ſame time known.

One ſolid Cubic foot of	*weighs*	*ounces* Avoirdupois.
Pure lead		11270
Pure tin		7170
Tin 32 parts, lead 1		7321
Tin 16, lead 1		7438
Tin 10, lead 1		7492
Tin 8, lead 1		7560
Tin 5, lead 1		7645
Tin 3, lead 1		7940
Tin 2, lead 1		8160
Tin 1, lead 1		8817

SECT. 298. (Additional.)

Native Tin.

The exiſtence of native tin has long been queſtioned; but it has undoubtedly been found ſome years ago in *Cornwall*, as Mr. Kirwan remarks [*a*].

1. Malleable tin, in a granular form, and alſo in a foliaceous ſhape, iſſuing out of a white hard matter like quartz; but which, after

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[*a*] Our Author ſaid, in his ſect. 181, that *tin is not found in the earth in any other ſtate than that of calx, cryſtallized*, &c. but theſe words were ſuppreſſed in the preſent edition; becauſe the contrary has been proved by facts, although not known in his own time. Likewiſe Profeſſor Bergman, in his *Sciagraphia*, ſect. 208, publiſhed in 1782, ſays, that ſome doubts were entertained of the exiſtence of native tin, perhaps not without reaſon. But this aſſertion ſeems rather inconſiderate, as it appears by his own *Theory of the Earth*, publiſhed in 1766 at Upſal, and quoted by Dr. J. R. Forſter, that he (Mr. Bergman) received an account from Mr. Quiſt, by which he aſſerts that Mr. Rinman had ſeen a ſpecimen of *native tin* in a ſoft ſtone, with cryſtallized quartz, and ſurrounded with a rind of *tin-zwitter*, or tin-ſtone. The ſame Dr. Foſter quotes alſo, in confirmation of this aſſertion, the vol. XXVII. p. 231. of the *Swediſh Tranſactions*, and the *Syſtema Naturæ* of Linnæus, vol. III. p. 236. of the 12th edition.

And finally, Wallerius ſays, that it has been found in the Duchy of *Deuxponts*, in *Cornwall*, and at Malacca in the Eaſt Indies. *The Editor.*

being

being properly aſſayed, proved to be arſenical cryſtals, a circumſtance that evinces its being native tin; ſince the arſenic could not remain in this form, if the tin had been melted. It appeared like a thick, jagged, or ſcolloped lace or edging; and was found near St. Auſtle in Cornwall [*b*].

2. In the form of cryſtalline metallic laminæ, or laminated cryſtals, riſing ſide by ſide out of an edging, which ſhone like melted tin; they were almoſt as thin as flakes or ſcales of talc, interſecting each other in various directions, with ſome cavities between them, within which appeared many ſpecks and granules of tin, that could be eaſily cut with a knife: this was alſo found in Cornwall [*c*].

3. In

[*b*] A ſpecimen of this ſort was found in 1765, and ſent by Mr. William Borlaſe, author of the *Natural Hiſtory of Cornwall*, to the Muſeum at Oxford, where it may be inſpected. It was enveloped by an outer cruſt, of about one-eighth of an inch thick, of a browniſh ſtraw-colour; the ſecond or inner coat was blacker, cloſer-grained, with ſome faint appearances of whitiſh ſpecks, about one-third of an inch thick. Phil. Tranſact. 1766. p. 36.

[*c*] The lump or product, of this, and the preceding ſpecimen, was very richly impregnated with tin; and though the beſt tin-ore, in general, will not melt without flux, nor do twenty pounds of block-tin uſually produce more than 14 pounds of the metallic regulus; yet, this tin melted without any flux; and 20 ounces of it produced 16 of good tin, *viz.* at the rate of 80 per hundred. See the Phil. Tranſact. vol. LVI. p. 37.

3. In a maſſy form, more than one inch thick in ſome places, and incloſed in a kind of quartzous ſtone: or rather in an hard cruſt of cryſtallized arſenic [*d*].

SECT. 299. (181.)

Calciforme Ores of Tin [*a*].

1. In form of a calx, *Stannum calciforme.*
A. Indurated, or vitrified, *Induratum.*
1. Mixed

This ſpecimen was preſented by the ſame Wm. Borlaſe, and depoſited in the Collection of Foſſils of the Royal Society of London, where I ſaw it many years ago; but it may be now found in the Britiſh Muſeum, where that collection was removed, by a kind of ſurprize, without the majority of the members being apprized before hand of any ſuch intention.

According to E. M. Da Coſta, the tin of this ſpecimen is perfectly ductile and malleable, and bends between the teeth, giving the ſame cracking noiſe as tin does. It melts eaſily in an open fire; calcines in the fire, aud emits ſome ſmoke: being urged in a ſtrong fire, with borax, it detonates with ſmall phoſphoreſcent ſparks, as pure tin does: is corroded to a white calx in nitrous acid, and, by adding oil of tartar *per deliquium*, no precipitation was produced. *See the Phil. Tranſact.* already quoted. *The Editor.*

[*d*] This was a lump of tin-ore found in a ſtream work, near the Borough of *Granpont* in *Cornwall*, weighing near 12 pounds; and ſo well covered by its cruſt, that, but for its extraordinary weight, it might have paſſed unnoticed. The fragments ſtill in the poſſeſſion of Mr. Roſewarne in that place, prove by the granulated external ſurface, and ſhotten edge, to be native tin. *Phil. Tranſact.* for 1766, *page* 38.

[*a*] Theſe ores are remarkable for their great weight; their ſpecific gravity being from 5,955 to 6,750. *Kirwan.*

In

1. Mixed with a ſmall portion of the calx of arſenic, *Minera ſtanni vitrea arſenicalis.*
2. Solid tin-ore, without any determinate figure. Tin-ſtone.

It

In order to aſſay an ore of tin, Fourcroy directs to divide it into different pieces, and reduce them into a groſs powder; to ſeparate the earthy part by waſhing, and to roaſt the remainder in a covered earthen veſſel. In Germany they are roaſted in reverberating furnaces, to which an horizontal chimney is affixed to collect the ſulphur and arſenic that are found mixed in the ore; the roaſted ſubſtance is afterwards melted in the air-furnace, and run into moulds in order to form the pigs or blocks of tin for ſale.

To aſſay tin ores in the *liquid way*, has hitherto been thought impracticable; however, Mr. *Bergman* has contrived the following method, which is generally ſucceſsful. Let the tin ore, well ſeparated from its ſtrong matrix by waſhing, and reduced to the moſt ſubtle powder, be digeſted in concentrated oil of vitriol, in a ſtrong heat for ſeveral hours; to this, when cool, add a ſmall quantity of concentrated marine acid, and ſuffer it to ſtand for one or two hours; then add water, and when the ſolution is clear pour it off; and precipitate it by fixed mineral alkali. 131 grains of this precipitate waſhed and dried, are equivalent to 100 of tin in its reguline ſtate, if the precipitate conſiſts of pure tin; but if it contains copper or iron, it ſhould be calcined for one hour in a red heat, and then digeſted in nitrous acid, which will ſeparate the iron. *The Editor from* Kirwan.

Almoſt all the tin ores of Cornwall are in a calciform, and at the ſame time in an indurated glaſs-like ſtate. The *Zinnſtein*, or *Tinſtone* of the Germans, might ſerve as the general denomination of them; but only the irregular and compact ſpecies are called ſo. The cryſtallized tin-ſtones, on the contrary, are called *Zinngraupen*, if the cryſtals are diſtinct,

It reſembles a garnet of a blackiſh brown colour, but is much heavier; and has been conſidered at the Engliſh tin mines as a ſtone, containing

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and ſomewhat large; but *Zinnzwitter* are thoſe in which the cryſtals are ſmall and not ſo diſtinct, reſembling ſmall grains, ſcattered through a compact raw tin-ſtone, or a ſtone of any other kind.

Theſe ſpecies of Corniſh tin-ores differ from thoſe of Bohemia and Saxony, by containing much leſs *iron*, and leſs arſenic; and this is the cauſe of the preference the Engliſh tin in general obtains, above any other tin, *viz.* on account of its purity.

The common matrix of tin in theſe mines is the *killas*, already deſcribed at p. 261: and the *growan*. This conſiſts of *white clay*, mixed with *mica* and *quartz*, without any particular texture; which, when lamellar and hard, is called *Gneiſs* by the Germans; and is nothing elſe but decayed *granite*, in which the *Feldſpar* (Sect. 113.) has been broken down to clay.

The *Zinngraupen* from Cornwall is the moſt remarkable, though rare. It conſiſts of quadrangular priſms, or double quadrangular pyramids joined by their baſes, ſo that theſe cryſtals are octoedral; theſe are found at *Trevaunance* and *Soil-hole*, in the pariſh of St. Agnes. Similar priſmatic cryſtals, but of as ſmall a ſize as a hair, are found in tin-ſtone upon *Killas*, at Polgooth, one of the richeſt tin mines, which produces ſometimes a clear profit from 1000 to 1200 pounds *per* month.

The *Stream-tin*, is collected in the valleys of the tin-mountains in Cornwall, and yields a conſiderable quantity of this metal. The ſoil is dug ſeveral feet deep, and waſhed by water going over it, till the heavier particles of the ore remain at the bottom. Theſe are nothing elſe but the abraſions of the tin ores over the mountains, which are rolled down the declivities of the hills to lower grounds.

The ſtream-tin from Penſagillis is remarkable, on account of the native gold now and then met with in it; and found,

containing no metal, until ſome years ago it began to be ſmelted to great advantage [*b*].

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found, though very rarely, in pieces of the value of two or three pounds ſterling. It principally conſiſts of round, oval, and ſomewhat ſmooth pieces, from the ſize of a bean to that of a pea, and leſs, whoſe poliſhed ſurfaces ſhow a variety of reddiſh, grey, light-brown, and dark yellow colours.

The *wood-tin*-ore looks like hematites, and is found only in the Pariſhes of St. Columb, Roach, and St. Denis. This is without any cryſtallized form; and has a very inconſiderable quantity of iron with it.

Another wood like tin ore, deſcribed by Profeſſor Brunnich, ſhows various fine fibres converging to different centres, like the radiated zeolyte; but is ſo compact and hard, as to ſtrike fire with ſteel. Its ſpecific gravity at the 45° of Fahrenheit, is 580, and even 645. It contains ſome arſenic and a conſiderable proportion of iron; and gives ſometimes 63,5 *per cent.* of tin. It is very ſcarce, and found only in ſmall bits. *The Editor from the Treatiſe of* M. H. Klaproth, *publiſhed when this ſheet was going into preſs.*

[*b*] The *Tin-ſtone*, *Zinnſtein* of the Germans, *Tenberg* of the Swedes, conſiſts chiefly of ſtones and ſands of different ſorts, which contain calx of tin inviſibly diſſeminated through them. Their ſpecific gravity, when the proportion of tin is conſiderable, is very great. They may be of any colour: The *blue*, *grey*, *black*, or *brown*, are the commoneſt. They are vulgarly called *lode-ſtones*.

N. B. 1. The ore called *Weiſs Zinngraupen* by the Germans, is that which was mentioned under the calcareous genus by the name of Tungſten. (See p. 46 and 47 of this edition;) but this ore contains no tin.

2. When any arſenic is found in tin, it proceeds from it's matrix; for tin itſelf is never found mineralized by it, but only mixed therewith. And under the ſame circumſtances zinc is ſometimes found in tin.

3. It is remarkable that tin has not as yet been found in any ſtones of the *calcareous* genus, except *fluors*; but in thoſe of the *ſilaceous* or *argillaceous kind*. *The Editor from* Kirwan.

SECT. 300. (Additional).

Calciform Tin Ores cryſtallized [a].

The tin ſpar, or white tin ore, is generally of a whitiſh or grey colour; ſometimes it is *yellowiſh, ſemi-tranſparent*, and *cryſtallized*, either of a pyramidical form, or irregularly. It was formerly thought to contain arſenic, but Mr. Margraaf found it to be the pureſt of all tin-ores; though it is ſaid to contain ſometimes a mixture of calcareous earth. Its ſpecific gravity is = 6,007. *Kirwan.*

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[a] The Tin-ſpar reſembles a white calcareous ſpar; but its conſtituent parts are more compact, and its weight greater. Some writers, and even our author, have doubted whether it contained tin. It is found, though very ſeldom, at Shlakkenwalde in Bohemia; and contains tin, as I am credibly informed. But there is likewiſe a heavy mineral very like *tin-ſpar*, without any particle of this metal in it. *Brunnich.*

Tin ore reſembling quartz, I have ſeen in Mr. De l'Iſle's cabinet at Paris. Its colour is white, and it ſeems to be mineralized by the aerial acid. *Fabroni.*

SECT.

SECT. 301. (Part of § 181.)

Tin Grains [*a*].

This ore like the garnets, is of a ſpherical polygonal figure; but ſeems more unctuous on its ſurface.

1. In large grains.
2. In ſmall grains*.

SECT. 302. (182.)

Calces of Tin, mixed with Metals.

1. Tin is found mixed with the calx of iron, as in the garnet. *See Sect.* 117 [*b*].

2. Tin

[*a*] The *opake, brown,* or *black tin-ore,* is alſo cryſtallized, and imbodied in a ſtrong matrix of quartz, fluor or mica; or mixed with white or yellow pyrites; or in ores of lead or zinc, cobalt, or iron. When theſe cryſtals are large, they are called by the Germans *Zinngraupen,* and when ſmall *Zinn-zwitter.* The *black* are reckoned the richeſt, and afford about 80 *per cent.* of tin. They all contain a mixture of iron. *The Editor from* Kirwan.

[*b*] Bergman ſpeaks alſo of ores of tin in the ſtate of calx, contaminated by iron, in the *ſect.* 209 of his *Sciagraphia*:

And the *zinn-zwitter* of the Germans already mentioned in the Note to the laſt Section 299, p. 630; contains alſo ſome mixture of iron, as Kirwan aſſerts.

Wallerius

* *See the* Notes *to p.* 629 *and* 630.

2. Tin mixed with Manganeſe. *See* Sect. 117 *of the Author, which will be inſerted among the* ſemi-metals.
3. Tin mineralized with ſulphur and iron [*c*].

Wallerius aſſerts that the ſtriated tin-ore from Siberia, which has the appearance of amianthus, called by the Swediſh *Strælig Tenmalm*, and by the Germans *Strahlichtes Zinnerz*, is mineralized by arſenic and iron. But this mineralization of tin ſeems very doubtful, inſomuch, that Kirwan poſitively aſſerts, that tin itſelf is never mineralized by arſenic. *See Note* [*b*] N° 2. p. 631. The Editor.

[*c*] The Noble Author had the miſtaken, but plauſible notion, that *plumbago*, or *black-lead*, was a compound of *ſulphur*, *tin*, and *iron*. Indeed the ſhining appearance of the *aurum muſivum*, to be mentioned in Sect. 303, which is a compound of tin and ſulphur, was a very ſpecious indication to adopt ſuch a ſuppoſition: he had ſaid, in the words that have been ſuppreſſed in the beginning of his Sect. 154 (*viz.* 231 of this Edition), *if ſuch a mixture of* ſulphur, iron, *and* tin, *be not rendered too volatile, it muſt be ſuppoſed that the great loſs the* black-lead *ſuſtains in the calcining heat, is occaſioned from the* ſulphur: *and that the* ſulphur *conſequently makes out the greateſt part of the* black lead. But the true analyſes of the *plumbago*, which have been repeatedly made ſince the Author's time, demonſtrate, that black-lead has very different component parts, as was ſhewn in Section 231; and is alſo of a very different nature from Molybdena, which the author thought to be only a variety of plumbago; it being of a metallic nature, as will be ſaid in it's proper place hereafter, among the ſemi-metals. *The Editor.*

SECT.

SECT. 303. (Additional.)

Aurum muſivum.

Tin mineralized by ſulphur was lately diſcovered by *Prof. Bergman*, among ſome minerals which he received from *Siberia* [*a*]. He obſerved two ſorts of it analogous to the two artificial combinations of tin with ſulphur.

1. One nearly of the colour of zinc, and of a fibrous texture, which contained about twenty *per. cent.* of ſulphur, and the remainder tin.
2. The other inveloped the former like a cruſt; reſembled *aurum muſivum*; and contained about forty *per cent.* of ſulphur, a ſmall proportion of copper, and the remainder tin. *Mem Stock*, 1721, p. 328. *Quoted by Kirwan* [*b*].

At

[*a*] This ore was found at *Nerchinſkoi* in Siberia. The part reſembling *aurum muſivum*, was the outſide cruſt, and in the middle was a nodule of a white metallic appearance, ſimilar to crude antimony, although it did not contain any. This was radiated from the center outwards; could be eaſily cut with the knife, after which the ſurface appeared of variegated colours; and being pounded, produced ſome black powder. Both theſe ſubſtances were contaminated by a ſmall quantity of copper. *The Editor from* Bergman.

[*b*] This account of the new ore of tin, given by Bergman in the ſaid Memoirs of Stockholm, has been tranſlated into French, and inſerted in the *Journal de Phyſique* for

At *Huel Rock*, in St. Agnes in Cornwall, there has been found a metallic vein, 9 feet wide, at 20 yards beneath the ſurface. Mr. Raſpe was the firſt who diſcovered this to be a ſulphurated tin-ore: it is very compact, of a bluiſh-white colour, approaching to grey-ſteel, and

for May 1783, pag. 367. It is directly aſſerted there, that the proportions of the component parts of this ore, *could not be aſcertained*, on account of their minuteneſs. From hence it is evident, that thoſe proportions, mentioned by Bergman in the *Preface* to his Sciagraphia, where he ſpeaks of the ſame new ore of tin, amount to no more than to a ſimple gueſs, from the comparative doſes, he mentions in the ſaid memoir, for producing by art two ſimilar ſubſtances; the firſt by melting 20 *per centum* of ſulphur with tin in a crucible, which produces a ſhining maſs, like zinc, that has a radiated appearance when broken; but if the quantity of ſulphur be double (*viz.* 40 *per centum*), and the fire is ſtronger, a ſhining yellow maſs is formed, which is compoſed of very ſmall and thin ſcales, like the *aurum muſivum*, or *muſaicum*, as others call it.

The proceſs given in the London Diſpenſary, for making artificial *aurum muſivum*, conſiſts in melting 12 *ounces* of of tin, in a crucible, and adding, after it is fuſed, 6 *ounces* of pure mercury. This brittle amalgam, after being cold, is pounded, and mixed with 6 *ounces* of ſal ammoniac, and 7 *ounces* of flowers of ſulphur. The whole is ſublimed in a matraſs: and the *aurum muſivum* will be found in the ſublimated matter, and ſome little droſs. Mr. Woulfe ſays, in the *vol.* LXI. of the Phil. Tranſact. p. 125, that 3 *ounces* of *mercury*, and as many of *ſal ammoniacum*, is ſtill a better proportion of the above ingredients; and that the *aurum muſivum* ſo produced, amounts then to 17½ ounces, whilſt that of the former doſes, gives only 16 ounces. This proceſs requires a graduated fire in the beginning, which muſt be increaſed, and continued for the ſpace of 5 or 6 hours. *The Editor.*

According

and ſimilar to the colour of grey copper-ore: it is lamellar in its texture, and very brittle. It conſiſts of *ſulphur*, *tin*, *copper*, and ſome *iron*. Mr. Raſpe propoſes to call it *Bell-metal-ore* [c].

SECT. 304. (183.)

Observations on Tin.

It has indeed been aſſerted by ſome, that tin is found native in the earth; but, for my own part, like many others, I doubt much of it, having never ſeen a ſingle ſpecimen that could be called native tin [*a*].

It

[*c*] According to Mr. Klaproth's analyſis of this ore, 119 grains contain 30 of pure *ſulphur*; 41 of *tin*; 43 of *copper*; 2 of *iron*; and 3 gr. of the *Stony matrix*. In another ſpecimen of the ſame ſulphurated tin-ore from Cornwall, there were in the *hundred* 25 parts of *ſulphur*, 34 of *tin*, 36 of *copper*, 3 of *iron*, and 2 of the *ſtony matrix*.

[*a*] 1. The contrary to this opinion of our author, has been fully demonſtrated in *Sect.* 298, *note* [*a*].

2. Tin, though ſometimes unmixed in its ores, is often otherwiſe; they frequently contain both iron and copper. The fire, with which tin is melted, is ſufficiently ſtrong to ſmelt alſo the other metals contained in the ſame ores; and hence, without any fraudulent proceeding in the tin-ſmelter, there may be a variety of other ſubſtances in its maſs. But this natural variety is far leſs than that which is fraudulently introduced; becauſe tin is above five times dearer than lead; and as a mixture, conſiſting of a large portion of tin with a ſmall one of lead, cannot be eaſily diſtinguiſhed from a maſs of pure tin, the temptation to adulterate it is great, and the fear of detection ſmall.

3. In

It is, however, remarkable that tin is ſo ſcarce, and is not found in any conſiderable quantity

3. In *Cornwall* the tin, after being ſmelted from the ore, is poured into quadrangular moulds of ſtone, containing about 320 pounds weight of metal, and it is then called *block-tin*. The officers, appointed by the Duke of Cornwall, aſſay it, by taking a piece of one of the under corners of each block; and, if found pure, it is ſtamped with the ſeal of the Duchy. It is clear, that if the tin is mixed with lead, this by its ſuperior weight ſinks to the bottom, and will be liable to be diſcovered, when the under corner is employed in the trial. But this ſeal gives no ſecurity for the goodneſs of the tin ſold abroad, ſince it is known, and Neumann aſſerts it (p. 131 of his firſt vol. in 8vo), that in Holland, every tin-founder has Engliſh ſtamps; and whatever his tin be, the inſcription *block-tin* makes it paſs for *Engliſh*. Watſon.

4. Whenever the filings of tin, held over the flame of a candle, yield a ſmell reſembling that of garlic; it contains an arſenical mixture: the moſt part of common tin is in this caſe; and ſome think that the crackling noiſe in bending, which is ſuppoſed to be an eſſential property of pure tin, belongs only to ſuch as is arſenicated; for after thoſe chemical operations, by which the arſenic is ſeparated, the tin is deprived of that noiſe.

5. Tin melted with arſenic, falls in great part into a whitiſh calx; the part which remains uncalcined, proves very brittle, appears of a white colour, and ſhows a ſparkling plated texture, greatly reſembling zinc. The arſenic is very ſtrongly retained by the tin, ſo as ſcarce to be totally diſſipable by any degree of fire, though the mixture be urged for a length of time, with a very intenſe heat. The tin, after being recovered by fuſion with inflammable fluxes, diſcovers, by its appearance, by its brittleneſs, and by its augmentation of weight, that it ſtill holds a conſiderable portion of the arſenic. *Lewis.*

6. Tin expoſed to a very violent heat, produces a whitiſh and brilliant flame; a white ſmoak riſes; which condenſes

into a whitiſh needle-form calx, which is called *Tin flowers*. Mongez.

7. Neumann obſerved, that on mixing iron and tin in the focus of a Tſchirnhauſen's burning-lens, if the tin was melted firſt, and the iron added, they united together very quietly; but when the iron was melted firſt, the addition of tin occaſioned a crackling, and a ſputtering of little globules, which burſt with a conſiderable ſnap; and inſtead of fumes, there aroſe exceeding fine filaments, which ſtuck to the cloths, &c. like cobwebs.

8. This kind of detonation, produced by the union of tin with iron on a very violent fire, and the extreme eagerneſs with which it is attacked by nitrous acid, as mentioned, *note* [*g*] to Sect. 297. may well account for that curious deflagration deſcribed by Dr. Higgins in the vol. LXIII. p. 137 of the Phil. Tranſact. which I have repeated a great many times to ſome curious perſons of my acquaintances. Several ſmall pieces of cupreous nitre (a ſalt which reſults from the ſolution of plated copper in nitrous acid, after evaporation, or nearly ſo) being put in a piece of tin-foil, with a very few drops of water, and being quickly rolled or wrapped up, with the extremities bent up, and pinched together: 1. the ſalt deliqueſces in the inſide of the tin: 2. this laſt changes its colour: 3. a froth iſſues out at the ends of the coil: 4. then a conſiderable warmth is produced: 5. it emits nitrous fumes: 6. an intolerable heat follows: 7. and at laſt it burſts with an exploſion and fire, fuſing the tin-foil in ſeveral places. In this caſe, the acid being moiſtened, quits the copper, and acts at once on the large ſurface of the tin, with ſuch an eagerneſs as to kindle its phlogiſton into a blaze.

9. Macquer obſerved, that putting a good quantity of granulated tin in a matraſs over the fire, the marine acid, which he poured upon it, immediately loſt its own fumes; attacked the tin with a ſenſible but moderate effervescence, and diſſolved it to ſaturation. The ſolution was as white and tranſparent as pure water, and diſſolved above the half of its weight of tin. When kept for ſome time in a glaſs veſſel, it cryſtallized during the cold weather, but became fluid in the ſummer. Cryſtals of tin may be formed by the ordinary method, which are of great uſe in the *calico-printing* proceſſes. *The Editor.*

The

quantity or purity in any other places in Europe, than in England and Saxony [b].

It

[b] The largeſt quantities of tin are met with in England, particularly in the county of Cornwall. There is ſome alſo in Bohemia and Saxony, as well as in the Eaſt-Indies; but in other countries it is rare to find ſo much as to be worth the trouble and expence of extracting.

2. Britain is ſuppoſed to have received its name from its abounding with this metal. For tin being called *Bragmanack*, in the Syriac and Chaldaic languages, that is, the kingdom of Jupiter; from hence ſeem to have been deduced the words *Bratman*, *Britman*, and *Britania*. Newmann.

3. The uſes of tin are very various. It is employed in a great number of arts. Its uſe, when united to mercury for making looking-glaſſes, has been already deſcribed in note N° 18. to Sect. 296. p. 608. Biſhop Watſon ſeems inclined to believe, on very good grounds, that the art of making looking-glaſſes, by applying to their back-ſurface a metallic covering of tin-plate imbibed by quickſilver, is not a very modern invention; and quotes the great Pliny, who aſſerts, that the Sidonians had invented ſomething of this kind. *See* vol. IV. *of his* Eſſays p. 250.

4. Thoſe metallic plates, generally called *tin* by the Engliſh, and more properly *fer-blanc* by the French, are merely iron-plates, very thin, which, on being dipped in melted tin, become quite covered by it, and form a very uſeful material for making a great variety of veſſels and utenſils of general uſe: particularly kitchen veſſels, ſauce pans, and other implements for the purpoſes of dreſſing all ſorts of food on the fire. Theſe are the moſt wholeſome veſſels, and the only ones that can be employed with ſafety; whilſt thoſe made of copper are highly dangerous, even when newly tinned in the inſide; for if any ſmall corner, or part of the ſurface, eſcapes the attention of the workman, or if the covering wears out without being obſerved, ſome verdigreaſe may be there generated; and this, when taken with the victuals, never fails of cauſing terrible effects on the animal body, and often inevitable death. It is much to be wondered indeed! that

It is likewiſe worthy of obſervation, that when its ore is profitable, or to be worked to any advantage

that the numerous diſaſters that repeatedly happen all over Europe and elſewhere, have not yet determined mankind to exterminate, abſolutely, every ſort of copper-veſſels and all other utenſils of copper from their kitchens.

5. It is certain that neither vegetable acids, nor diſtilled vinegar, diſſolve any ſenſible quantity from tin; and it was on this account that copper veſſels for culinary purpoſes, are generally tinned in the inſide, to prevent the poiſonous effects of verdegreaſe being produced, and mixed with the food prepared in ſuch veſſels; but, beſides the deficiency already mentioned, that may happen in the tinning, the metal commonly employed for this purpoſe, conſiſts of 5 parts of pewter and 3 parts of lead. Now it is known, that lead is eaſily attacked by vegetable acids; and if it happens to be taken internally, never fails of producing dangerous and chronic diſeaſes, the *colica Pictonum*, *palſies*, &c. So that after due conſideration, *tinn'd iron*, and *tin-plate*, are the only cheap and wholeſome materials for veſſels for kitchen uſe.

6. This tin-plate, laſt-mentioned, is nothing elſe, but ſheets or plates of iron, that have been hammered, or, which is better, flattened to a proper thickneſs, by paſſing the hot iron, between two iron cylinders caſed with ſteel; they are then cut to a proper ſize, and ſteeped in a ſolution of ſal-ammoniac, or in an acid liquor, produced from the fermentation of barley meal, though any other weak acid would anſwer the purpoſe; after this ſteeping, they muſt be well ſcoured, ſo that the whole ſurface may be very clean and quite bright. They are then dipped into an iron pot filled with melted tin, whoſe ſurface is covered with ſuet, or fat, and pitch. The plates come out with both the ſurfaces covered with the tin: and as they poſſeſs the cleanlineſs of the tin, added to the rigidity of the iron, they are of great uſe for many purpoſes of common life.

7. Pewter, which is commonly called *etain* in France, and generally confounded there with true tin, is a compound

advantage, it is always in form of an indurated calx, which reſembles thoſe glaſſes that are prepared from metallic calces in our laboratories.

Therefore, in ſpeaking of this reſemblance, in order to render this Mineralogical Eſſay more intelligible to the reader, I have uſed the term *calx*, in deſcribing the metals; by which word is underſtood

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metal, whoſe baſis is tin. The beſt ſort conſiſts of tin allayed with about a twentieth, or leſs, of copper or other metallic bodies, as the experience of the workmen has ſhewn to be the moſt conducive to the improvement of its hardneſs and colour, ſuch as *lead*, *zinc*, *biſmuth*, and the metallic, or reguline part of *antimony*. There are 3 ſorts of pewter, diſtinguiſhed by the names of *plate*, *triſle*, and *ley-pewter*. The firſt is uſed for plates and diſhes; the ſecond for the *pints*, *quarts*, and other meaſures of beer; and the lay-pewter is uſed for wine meaſures, and large veſſels.

8. The beſt ſort of pewter conſiſts of 17 parts of regulus of antimony to 100 parts of tin; but the French add a little copper to this kind of tin. A very fine ſilver looking metal is compoſed of 100 pounds of tin, 8 of regulus of antimony, 1 of biſmuth, and 4 of copper. On the contrary, the *ley* pewter, by comparing its *ſpecific* gravity with thoſe of the mixtures of tin and lead, already mentioned in the table at page 625, muſt contain more than a fifth part of its weight of lead. This quantity of lead is far too much, conſidering ſome of the uſes this ſort of pewter is applied to; for acid wines will readily corrode the lead of the flagons, in which they are meaſured, into ſugar of lead, which being taken internally, is productive of various chronic diſeaſes, as the *Colica Pictonum*, *palſies*, *ſtupors* in the limbs, &c.

9. Foreigners generally aſſert, that Engliſh tin is always a mixed metal when exported abroad: and the French Encyclopediſts in particular (article *etain*) inform us, on the authority of Mr. Rouelle, that the Engliſh tin, when caſt into moulds,

underſtood the ſame as the chemiſts call a *crocus*, or *terra metallorum privata.*

. . . . . .

The words here ſuppreſſed, related to the miſtaken notion of the Author already mentioned in Note [c], *to Sect. 302. p. 634.*

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moulds, of 6 inches in thickneſs, and cooled, if it be divided into 3 layers, the uppermoſt has 3 pounds of copper on the 100 of tin: the ſecond layer has 5 pounds of lead to the ſame quantity of tin; and the loweſt layer has 9 of lead to the hundred of tin. Geoffroy had formerly given a ſimilar account of the Engliſh tin, with ſome variety in the doſes. But there never was any other foundation for ſuch an aſſertion, than that *pewter* has been miſtaken for *tin* abroad: and in fact all pewter-diſhes and all other pewter-pieces are called by the name of tin-ware all over Europe, except in England. Nor could there ever be any advantageous motive to hinder the export of pure tin from England, where it is found in a greater abundance than any where elſe. Beſides the above, neither Borlaſe nor Pryce, who wrote ſo minutely on the method of preparing tin in Cornwall, mention any operation or mixtures this metal undergoes or receives, before or after it is caſt into the ſlabs, blocks, or pieces of tin, in which *ſize*, and *form*, it is ſold, and ſent to every market in Europe; ſo that the whole muſt be a miſtake in terms, as already mentioned, by taking *pewter* ſimply for tin.

10. The calx of tin, known by the name of *Putty*, is generally uſed to poliſh various hard bodies, as glaſs, metallic ſpecula for reflecting teleſcopes, &c. When fuſed with lead and ſand it produces enamel; and ſerves alſo to cover earthenware, giving to it a glaſſy and neat ſurface for uſe. *The Editor, chiefly from Watſon's* Eſſays.

SECT. 305. (184.)

Lead. *Plumbum*, *Saturnus*, Lat. *Bley*, Germ. *Bly*, Swed. *Plomb*, French.

General Properties of Lead.

a. This metal is of a blueiſh white colour when freſh broke, but ſoon becomes dull or tarniſhed in the air [*a*].

b. Is very heavy; viz. to water as 11,325 to 1000 [*b*].

c. Is the ſofteſt next to gold, but has no great tenacity, and is not in the leaſt ſonorous [*c*].

It

[*a*] Lead is not ſubject to be much corroded by expoſure to air or water; though after long ſtanding, a thin cruſt is formed on its ſurface, which is a fine calx of lead formed by the aerial acid, that ſlowly decompoſes it. *Monnet.*

[*b*] According to Bergman, the ſpecific gravity of lead is = 11,352: Kirwan ſays, however, that it reaches from 11,300 to 11,479. According to Watſon, an Engliſh cubic foot of new lead weighs 11,262 ounces of *avoirdupoids*; but of lead reduced from *minium*, it weighs 11,460. See the table at page 625.

[*c*] The Author means undoubtedly, that lead is the ſofteſt of all metals, except pure gold, with regard to its pliancy or flexibility; but its tenacity is very inconſiderable; and conſequently it is incapable of being drawn into a fine wire.

Under the hammer, it is eaſily extended into thin plates; but its properties, as Nicholſon obſerves, have not induced practitioners

d. It is eaſily calcined; and, by a certain art in managing the degrees of the fire, its calx becomes white, yellow, and red [*d*]. This

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practitioners to ſubject it to the ſame trials as *gold*, *ſilver*, and *copper*. A wire of this metal, *one-tenth* of *an inch* thick, cannot hold a weight above 29 pounds and a quarter, without breaking. *Monge*.

Lead has a remarkable ſmell, which is very diſtinctly perceived when rubbed. *Fourcroy*.

[*d*] Lead, mixed with tin, calcines ſooner than by itſelf alone: one pound of this laſt quickly incinerates 10 pounds of lead. *Neumann*.

By calcination, lead is converted into a duſky powder called *plumbum uſtum*; a longer continued heat, with acceſs of air, renders it *white*, *yellow*, and afterwards it becomes of a *bright red*, inclining to *orange colour*, called *minium*, or *red lead*. The heat for this purpoſe muſt not exceed a certain degree. A greater heat converts this ſubſtance by degrees, into a *yellow* flaky calx, called *Litharge*; and, by a moderately ſtrong fire, it runs into a *yellow tranſparent* glaſs, which powerfully diſſolves metallic calces; and, unleſs combined with theſe, or earthy additions, corrodes and paſſes through common crucibles. This glaſs acts more ſtrongly on *ſiliceous* than on *argillaceous* earths, and is a principal ingredient in fine white flint-glaſs. *Nicholſon*.

The red-lead, or *minium*, may be made directly from *lead*, and alſo from *litharge*, which has already been ſaid to be the half vitrified calx of the ſame metal, and can be had cheaper from various proceſſes where lead is employed. But this laſt red lead is not ſo good as the former, on account of the ſcoria of other ſubſtances mixed therewith; particularly the makers of flint-glaſs, who uſe much red-lead in the compoſition of that glaſs, find that it does not flux ſo well as that made from the direct calcination of the metal, as practiſed in the county of *Derby*, where no leſs than nine mills or furnaces are kept on this operation. Theſe furnaces are very like a baker's oven, with a low

e. This calx melts more eaſily, than any other metallic calx, to a glaſs, which becomes of a yellow colour, and ſemi-tranſparent. This glaſs brings other bodies, and the imperfect metals, into fuſion with it.

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vaulted roof, and two party-walls, riſing from their floor, which leave a middle ſpace, where the pit coal is burned: the flame being drawn over the party walls, ſtrikes on the roof, and is from thence reflected on each ſide, by which the lead there kept is melted. The ſurface of lead, by its expoſition to air, becomes inſtantly covered with a duſky pellicle; this is ſucceſſively removed, and the greateſt part of the metal is converted into a yellowiſh-green powder. This is afterwards ground fine in a mill, and waſhed; the heterogeneous particles of lead, ſtill in being, are ſeparated by paſſing the waſh through ſieves: the yellow colour becomes uniform, and is called *Maſſicot* by the painters. Theſe yellow calces, being well dried, are thrown again into the furnace, where they are conſtantly ſtirred in a continued heat; ſo that in about 48 hours, theſe calces acquire a *vivid red* inclining to *orange colour*, and are known by the name of *Minium*, or *red-lead*. Mr. de Machy was certainly miſtaken, when he aſſerted that the calcination alone, without the contact of the flame and ſmoke, was capable of producing a good colour. But the red-lead made in France is of a conſiderably worſe quality, than what is made in England, or Holland. A ton, or 20 hundred weight of lead, generally gives 22 hundred weight of minium. It is ſaid, that at Nuremberg the increaſed weight of red-lead amounts to one-fifth of the metal; this may probably depend on the method employed, as Watſon thinks. Neumann ſays, that the beſt Venetian minium is made out of ceruſſe, or white lead.

The litharge, already mentioned, is called *Litharge of Gold*, when its colour inclines to *yellow*; and of *ſilver*, when it is *whitiſh*; but neither of them contains any portion of theſe precious metals. *Neumann.*

It

f. It diſſolves, 1ſt, in the ſpirit of nitre; 2dly, in a diluted oil of vitriol, by way of digeſtion; 3dly, in the vegetable acid; 4thly, in alcaline ſolutions; and 5thly, in expreſſed oils, both in the form of metal and of calx [*e*].

g. It gives a ſweet taſte to all ſolutions.

h. It amalgamates with quickſilver.

i. With the ſpirit of ſea-ſalt it has the ſame effect as ſilver, whereby is produced a *ſaturnus corneus* [*f*].

It

[*e*] Lead diſſolves in *nitrous acid* into a yellow liquor. This ſolution inſpiſſated, explodes or fulminates in the fire. *Neumann.*

Proof *aqua fortis*, lowered with an equal quantity of water, diſſolves half its weight of lead. This ſolution, according to Lewis, being diluted with water, becomes milky, and depoſits the metal. But Fourcroy denies this fact in his vol. I. p. 512 of the Engliſh edition. The ſame ſolution, after exhaling very ſlowly to the air part of the menſtrum, ſhoots into ſmall pyramidal cryſtals with ſquare baſes, of an auſtere ſweet taſte. *Lewis.* Fourcroy ſays, that theſe pyramids are hexaedral.

Vitriolic acid, aſſiſted by a boiling heat, corrodes half of its weight of lead into a ſaline maſs. This acid precipitates the metal from its *nitrous* and *marine* ſolutions. *Lewis*, and *Kirwan.*

[*f*] Pure marine acid, with the aſſiſtance of heat, readily calcines lead, and diſſolves part of its calx; but it is difficult to ſaturate it compleately. By a ſtrong evaporation, it produces cryſtals in the form of fine and brilliant needles, according to *Monet* quoted by *Fourcroy*. This metal combines more readily and intimately with marine acid, when this menſtrum is poured either uncombined or united with an earthy or alkaline baſe, into the ſolution of lead in nitrous acid.

k. It does not unite with iron, when it is ſingly added to it in the fire.

l. It works on the cuppel, which ſignifies that its glaſs enters into certain porous bodies, deſtitute of phlogiſton, and alcaline ſalts.

It

A copious white precipitate is then immediately formed, reſembling a coagulum; which is a new combined ſalt, that falls down, on account of its great inſolubility. If expoſed to the fire, vapours of a ſaccharine taſte are diſengaged: and it fuſes into a brown maſs, called *Plumbum Corneum*. Fourcroy.

The acetous acid diſſolves lead and its calces. *White-lead*, or *ceruſe*, is made by rolling leaden plates ſpirally up, ſo as to leave the ſpace of an inch between each coil, and placing them vertically in earthen pots, at the bottom of which is ſome good vinegar. The pots are to be covered and expoſed for a length of time to a gentle heat, in a ſand-bath; or elſe they are covered with dung. The vapour of the vinegar attaches itſelf to the ſurface of the plates, and corrodes them, reducing the ſame by that means into *ceruſe*, which comes off in flakes, when the lead is uncoiled. The plates are thus treated repeatedly, till they are corroded through.

The acid in the *ceruſe* is ſuper-ſaturated. By a ſolution of this compound in acetous acid, a cryſtallizable ſalt, called *ſugar of lead*, is obtained, which is the ſame as would, with leſs facility, have been procured by diſſolving lead directly in that acid. *Nicholſon.*

All ſolutions of lead are precipitated black by the *liver of ſulphur*: and then a ſort of *Galena* is formed, the ſulphur being depoſed upon the calx of lead; which ſeems to indicate, that the lead, in this ore, is in a calciform ſtate. *Fourcroy.*

The calces of lead are much affected by ſulphureous vapours of all kinds. Even metallic ſalts, which have lead for their baſe, eſpecially *ſaccharum ſaturni*, change colour by the vicinity of ſuch vapours. This ſolution of ſugar of lead may ſerve as a ſympathetic ink. A letter written with it, on being expoſed to the vapour of ſulphur on lime-water; the

inviſible

m. It melts in the fire before it is made red-hot, almoſt as eaſily as tin [g].

Its

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inviſible vapours that riſe from it, will blacken the writing, although the letter be put between two or three hundred leaves of paper.

Oils and fats have a ſtrong action on lead, and its calces. Litharge, or any other calces of lead, are copiouſly and intirely ſoluble in oils by boiling, which are thereby rendered thicker, and more drying. Linſeed oil, thus impregnated with litharge, is much uſed by painters on the account of the laſt quality: and is known under the name of *drying oil.* Many of the plaſters uſed in ſurgery have for their baſis an oil thickened by boiling with calx of lead. *Nicholſon.*

The topical preparations of calces of lead, known by the name of *Goulard*, have performed wonderful cures in numberleſs caſes, in which other applications have failed. *See the excellent Treatiſe of Goulard, in* 12mo. *London*, 1775. *The Editor.*

[g] Lead melts eaſily on the fire, long before its ignition, at about 595 degrees of Fahrenheit's thermometer, according to Bergman: but Lewis and Nicholſon affirm, that 540 degrees is ſufficient for the purpoſe: and that at this degree, its calcination will begin, if reſpirable air be preſent in the operation.

By the union of lead with tin and biſmuth in a due proportion, a compound metal reſults, which melts below the degree in which water boils. This mixture has been publiſhed by Dr. d'Arcet the celebrated profeſſor of chemiſtry at Paris. It conſiſts of three parts *tin*, five of *lead*, and eight of *biſmuth*. The doſes given by Newton, who firſt diſcovered this kind of metallic mixtures, and thoſe given by Margraaf and Homberg, require a higher degree of heat to melt. *See Journal de Phyſique* for March 1777, page 217.

As ſoon as pure lead melts, its ſurface is covered with a pellicle, which exhibits various ſucceſſions of colours; but a ſmall portion of tin or zinc, mixed with it, prevents this variegated appearance. The lead of thoſe metallic ſheets, with which the Chineſe boxes of tea are lined, does not exhibit,

n. Its calx or glaſs may be reduced to its metallic ſtate by pot-aſhes.

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hibit, when melted, thoſe variegated colours on its ſurface, no doubt on account of its mixture with other metals. The order in which theſe colours ſucceed one another, is the following; *yellow*, *purple*, *blue*, then *yellow*, *purple*, *green*, and twice *pink-green*. All theſe colours are very vivid with a proper heat; but if that is weak, that ſucceſſion of colours ſtops before it has gone through all the above changes. *Watſon.*

Melted lead, in a ſtrong red-heat, boils and emits fumes, which the workmen erroneouſly call *Sulphur*, for they are nothing elſe but the calcined parts of the metal that ſublime of a yellow and red colour. Watſon affirms, in his eſſays, vol. III. p. 344, that this ſublimate amounts to about *five hundred* weight in one hundred *tons*; viz. 500 in 200,000 pounds, or $\frac{1}{4}$ *per centum*.

If melted lead be poured into a box, previouſly rubbed with chalk (to prevent adheſion) and continually agitated, it will concrete into ſeparate grains, of conſiderable uſe in a variety of mechanical operations; or, if it be poured into a mould, and turned out at the inſtant of cooling, a blow with a hammer will break the maſs, and the ſymmetrical arrangement of the internal parts will be ſeen. *Nicholſon.* The like happens alſo to tin in ſimilar circumſtances, as was noted at p. 619.

When melted lead is ſuffered to cool very ſlowly, it cryſtallizes into quadrangular pyramids, laying ſideways one over the other. But all metallic ſubſtances have been found to have their particular cryſtallization, of which that of metals approaches to the pyramidical form, whilſt that of the ſemi-metals affects the form of needles, provided they be all properly managed in their cooling, as Mongez has ſhewn in the *Journal de Phyſique* of July for 1781, p. 74. *The Editor.*

SECT.

SECT. 306. (Additional.)

Native Lead. Plumbum Nativum.

Our Author, in the Sect. 191. of this mineralogy and ſome other mineralogiſts, doubted whether *native lead* was ever found in its metallic ſtate on the earth; but they never could ſhew any better grounds for their incredulity, than the deficiency of information; facts however are ſtubborn witneſſes, which cannot be defeated by mere aſſertions [*a*].

It appears by the *Phil. Tranſact.* for 1772, *pag.* 20, that ſome ſmall pieces of *native lead* were found in Wales, in the County of *Monmouth.*

Genſanne, in his *Hiſtory of Languedoc*, p. 208, of vol. III. aſſerts alſo, that this metallic ſubſtance was found native in the Vivarais. Henc-

[*a*] Bomare mentions (in his *Mineralogy*, vol. II. p. 176.) a curious ſpecimen of *native lead*, kept in the collection of Abbé Nolin at Paris, that had been found in the lead-mines of *Pompean*, near *Rennes* in Brittany. This metal was very malleable; could be cut with a knife without crumbling and eaſily melted over the flame of a candle. It weighed about two pounds; was imbedded in an earthy lead-ore of a reddiſh colour: and had a flaty vein that went through it. I think, that after ſuch circumſtances it can hardly be doubted of its being a natural production. *The Editor.*

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kel affirms likewiſe its exiſtence, in his *Flora Saturniſans*. See Kirwan's *Elem. of Mineralogy*, p. 297 and 298.

Wallerius (p. 301, of the 2d vol. of his Mineralogy,) aſſerts, that this metal has been found in its metallic form, in Poland, a ſpecimen of which was kept in the collection of Richter; and adds, that a ſimilar one, found at Schneberg, was ſeen in the collection of Spener.

Dr. Lawſon, in his Engliſh edition of Cramer's *Art of Eſſaying Metals*, ſays, at p. 147, that ſome *pure native malleable lead* had been lately found in *New England*.

And laſtly, the late celebrated Profeſſor Bergman did not heſitate to inſert, by itſelf alone, the *plumbum nativum*, in Sect. 180, of his *Sciagraphia*.

SECT. 307. (185.)

Calciform Lead.

Lead is found,

A. In the form of a calx, *Minera plumbi calciformis* [*a*].

Pure,

[*a*] The calciform ores of lead may be diſtinguiſhed into 5 varieties; *viz.* 1. The *white*, *lead-ſpar*, *lead ochre*, *native ceruſe*. 2. *Red*, *brown*, or *yellow*. 3. *Green*. 4. *Bluiſh*. 5. *Black*. All are mineralized by the *aerial acid*, or *fixed air*: are

1. Pure, *Minera plumbi calciformis pura.*
   a. Friable, lead ochre, *Ceruſſa nativa*, Native ceruſe, is found at Kriſtierſberget in Weſtmanland, on the ſurface of the potter's ore [*b*].
   b. Indurated, lead ſpar, or ſpatoſe lead ore, *Spatum plumbi.*
1. Radiated, or fibrous.
   White, from Mendip-Hills, in England [*c*].
   Criſtalliſed

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are ſoluble in nitrous acid, and effervesce with it, if heat be uſed; and are diſſolved alſo in expreſſed oils. All contain a little iron, but never any ſilver.

[*b*] Lead ochre, or native *ceruſe*, is the ſame ſubſtance; but either in a looſe form, or indurated, and ſhapeleſs; ſometimes it is found in a filamentous form, of a ſilky appearance. Both contain a little iron, and ſometimes calcareous and argillaceous earth: grow red or yellow when ſufficiently heated. They effervesce with acids, and afford from 60 to 80, or 90 *per centum* of lead; both are found in *Brittany*, *Lorrain*, *Germany*, and *England*. Kirwan.

Bergman made a ſeparate ſection of this *ceruſa nativa*, which is nothing elſe but this white lead-ore, mineralized by the aerial acid. *See the Sect.* 183, *of his* Sciagraphia.

[*c*] It is there found with the iron-ſtone and Manganeſe; but in ſmall quantities. Likewiſe at Zetterfield in the Hartz. *Brunnich.*

Mr. Sage of the Royal Academy at Paris, pretended that the *white* lead-ore, from Poulawen in the county of Bretagne in France, was mineralized by the *marine acid*: but this aſſertion was demonſtrated to be abſolutely erroneous by the commiſſioners of that Academy. *See* Journal de Phyſique. Tom. III. p. 348. for June 1774.

This ore, according to the ſame Academicians, is compoſed of ſtriated cryſtals, of a whitiſh pale red, or grey colour. There is a *white lead-ore*, ſometimes *grey*, and ſometimes yellow

2. Criſtalliſed in a priſmatick figure [*d*].

a White, from Norrgrufva in Weſtmanland.

Yellowiſh

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yellow, which is very heavy. Its ſtructure is either lamellated or fibrous, and its laminæ can hardly be ſeparated; but it is friable, and may be cut with a knife. Sometimes it is cryſtallized, and ſometimes its fibres are extremely thin, ſemi-tranſparent, and of a ſilky look, as deſcribed in the preceding note. They effervesce with acids, decrepitate on the fire, and ſeem to looſe the aerial acid, by which the lead is mineralized. Among the lead mines of France, England, Saxony, and other parts of Germany, many fine ſpecimens of this ore are often to be met with. *Mingez.*

[*d*] The ſparry lead has often a ſemi-tranſparency like the ſparry fluor; its cryſtals are generally truncated hexaedral priſms, or cylindrical columns, ſtriated, and ſeem to be compoſed of a great number of filaments; theſe ſparry cryſtals are always found in the ſame places with the *galena* or ſulphurated lead ores; and ſeem to be formed from their decompoſition, after the loſs of their ſulphur; for it is not rare to find galenas, which are beginning to paſs to the ſtate of white-lead.

Therefore the *black ore* of lead may be regarded as an intermediate ſpecies between the *white lead* and *galena*, as it ſeems to be a true white lead altered by the hepatic vapours of the ſulphur, on its parting from the galena.

The *green ſparry lead* is more or leſs tranſparent, and for the moſt part yellowiſh. It has frequently no regular form, and appears like a kind of moſs.

Theſe lead-ores are found chiefly in Hoffsgrund, and near Friburg in Briſgaw. When this green ore is criſtallized, it conſiſts of hexaedral truncated priſms, terminated by ſix-ſided pyramids, either intire, or truncated near their baſe. A great quantity of it is found at Sainte Marie-aux-mines, and at Tſchoppau in Saxony. *Fourcroy.*

The *green* and the *black* from Saxony, as well as the *blue* from Hungary, are priſmatic. *Brunnick.*

b. Yellowiſh green, from Zchopau in Saxony [*d*].

SECT.

[*d*] The *green lead ores* are either cryſtallized in needles, as in *Brittany*, or in a looſe powder as in *Saxony*; but moſt adhering to, or inveſting quartz. They owe the green colour to iron, ſeldom contain copper, and are very rare. *Kirwan* and *Mongez.*

Sapphire coloured. This was once found, together with ſome white-lead-ſpar, at *Wendiſh-Leuten*; and could be eaſily melted by the blow-pipe. Dr. Jacquin had this curioſity in his cabinet.' *Brunnich.*

This lead ore is ſometimes cryſtalized, ſometimes amorphous; it owes its colour to a mixture of copper. *Kirwan.*

Black. This ore is found, though very ſeldom, in Saxony.

The figure of theſe cryſtals is not always the ſame. The *white* ones come near to the ſhape of the ſelenite.

Red,' or *natural minium*, was found in Siberia: and a ſpecimen of it was kept in the collection of the late Prince Charles de Lorraine at Bruxelles. *Fabroni.*

Another *red lead* was found in the mines of Piroſew near *Catherinenburg* in Siberia. *Brunnich.*

The *red*, *brown*, or *yellow* lead-ore, is found either regularly cryſtallized, or in ſhapeleſs maſſes, or in powder. It differs from the white ſpar, and from the native ceruſe, only by containing more iron. That in powder, contains a mixture of clay. *Kirwan's* Mineralogy p. 299. See alſo what has been ſaid in the note at p. 524.

Dr. J. R. Forſter brought from Ruſſia ſome of this cryſtallized red lead ore, which I ſaw on his firſt arrival in England. They appeared to be nearly of a cubical form, and the red colour was rather pale. *The Editor.*

The *red* Siberian ones are perfectly rhombic; and the *green* from Bohemia have a cubical or rhomboidal form. Their colour depends on the adventitious particles. Lehman has found ſulphur and arſenic in the *red* ones: the others have not been ſufficiently inveſtigated; moſt of them effervеſce with acids. *Brunnich.*

The

SECT. 308. (186.)

Minera plumbi calciformis mixta.

a. Mixed with the calx of arſenic, *arſenical lead ſpar.*

1. Indurated.

a. White. I have tried ſuch an ore from an unknown place in Germany, and found that no metallic lead could be melted from it by means of the blowpipe, as can be done out of other lead ſpars; but it muſt be performed in a crucible, and then that part of the arſenic which did not fly off in ſmoke, during the experiment, was likewiſe reduced, and found in form of grains diſperſed, and forced into the lead.

Another ore of this kind, which likewiſe was not eaſily reduced by means of the blowpipe, did always after being melted, and during the cooling, haſtily ſhoot into poly-

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*. The *black-lead ores* are the moſt uncommon of all; and occur either cryſtallized, or of an indeterminate form. *Kirwan.*

A lead ore of a *purpliſh brown*, nearly reſembling the flower of the *peach-tree*, was found at Huelgoet in Brittany. It was a needle-formed cryſtallization; difficultly fuſible with the blow-pipe, and contained more iron than others; but it was eaſily reduced by the mineral alkali. *Mongez.*

gonal,

gonal, but moſtly hexagonal cryſtals, with ſhining ſurfaces. Can this cryſtalliſation be owing to ſalts, which are ſaid not to act in this manner, but when they are diſſolved in water?

b. With calcareous earth [*a*].

[*a*] This is the lead ore, deſcribed *Minera calciformis mixta terra calcarea majore portione*, of which our author has already treated in his Sect. 37 and 38. It effervesces with aqua fortis, and contains 40 *per cent.* of lead; on which account, it ought rather to be placed here than among the calcareous earths. M. Cronſtedt founded his claſſification upon the Swediſh minerals. There are in Scotland, and the northern provinces of England, indurated lead-ochres; but, for want of ſufficient experiments, their places in the ſyſtem are ſtill uncertain. *Brunnich.*

The abovementioned ores are very rich in lead, and eaſy to be tried; moſt of them, being ſlowly heated, may be reduced to lead, by means of the blow-pipe, on a piece of charcoal. The calx of the lead in theſe ores has, perhaps, firſt been diſſolved by ſulphur and arſenic, and afterwards, when theſe two have weathered away or decayed, have aſſumed this form; in the ſame manner, as we ſee it really happens during calcination, with rich lead ores, or ſuch reguli as contain lead. The ſame, very probably, is the caſe with other metals; for which reaſon their ores, when they occur in form of a calx, often contain a little ſulphur, and more eſpecially arſenic. *The Author.*

N. B. Moſt of theſe ores, mentioned in the notes to the preceding ſection 307, might as well have been treated of in this place; but it was thought better to ſet them down according to the references pointed out by Profeſſor Brunnich. *The Editor.*

SECT. 309. (187.)

Lead mineralized. *Plumbum mineraliſatum.*

1. With ſulphur alone, *Plumbum ſulphure mineraliſatum*: The *Bley-Schweiff*, or *Bley-glanz*, of the Germans.

a. Steel-grained lead ore, from the mines at Hellefors, in the province of Weſtmanland.

b. Radiated, or antimoniated lead ore.

c. Teſſellated, or potters lead ore.

At Villach in Auſtria there is ſaid to be found a potters lead ore, which contains not the leaſt portion of ſilver.

SECT. 310. (Additional.)

Lead mineralized by the Vitriolic Acid.

This ore was diſcovered by Mr. Monnet. It occurs ſometimes, though rarely, in the form of a white ponderous calx.

It is ſoluble in 16 or 18 times its weight of water.

Does not efferveſce, nor is it ſoluble in other acids.

It may be reduced, by the blow-pipe upon charcoal.

It

It ſeems to originate from the ſpontaneous decompoſition of the ſulphurated lead ores mentioned in the laſt Section.

According to Dr. Withering, another variety of this ore of lead mineralized by *vitriolic acid*, is found in great quantity, in the iſland of *Angleſey* near Carnarvonſhire in England: but it is united to *iron*; and is not reducible by the blow-pipe over charcoal. It is of a yellow colour, and contains ſome clay. The Doctor promiſes an accurate analyſis of this ore. *The Editor from* Kirwan, *and* Bergman.

SECT. 311. (Additional.)

Lead mineralized by the *Acid of Phoſphorus*.

This ore was lately diſcovered by Gahn.

It is of a greeniſh colour, by reaſon of a mixture of iron.

Melts upon the charcoal, with the blow-pipe; but does not effervesce with acids.

After ſolution in nitrous acid, with heat, the lead may be precipitated by vitriolic acid. 137 *grains* of this precipitate, after being waſhed and dried, afford 100 *gr.* of lead in its metallic ſtate; and the decanted liquor, being evaporated to dryneſs, produce the *phoſphoric acid*: which being mixed with powder of charcoal, affords real phoſphorus by diſtillation.

A ſmall piece of this ore, being melted by the heat of a flame, urged by the blow-pipe, aſſumes the form of a polyedral globule, whoſe facets, though apparently flat, are really compoſed of concentric ſtriæ, when obſerved by the microſcope.

Seven ounces of this green lead-ore from Hoffsgrund, near Friburg, capital of Briſgaw, in Swabia, being powdered, and diſſolved in the nitrous acid, on adding vitriolic acid, this united with the lead, and both precipitated: the remaining liquor being evaporated on a ſand heat, to the conſiſtency of Syrup, which was of a green colour, was mixed with powdered charcoal; and, on being urged by fire in a retort, produced about two gros (144 *gr.*) of a fine phoſphorus.

A ſimilar compound may be ſynthetically produced, if *pure* phoſphoric acid, (*viz.* combined with volatile alkali, for the natron of the microcoſmic ſalt hinders the production) be mixed with red-lead. *The Editor from* Bergman, Kirwan, and Mongez.

SECT. 312. (188.)

2. Lead with ſulphurated ſilver. *Plumbum argento ſulphurato mineraliſatum.* Galena: Alſo called *Bleyglanz* by the Germans.

a. Steel-grained, is found in the mines of Salberg and Hellefors, in the province of Weſtmanland;

Weſtmanland; and in the Dorothea-mine, on the Hartz in Germany.

b. With ſmall ſcales, is found at Salberg, and is there particularly called *Blyſchweif.*

c. Fine-grained, found at Salberg.

d. Of a fine cubical texture; and,

e. Of coarſe cubes. Theſe two varieties are found in all the Swediſh ſilver-mines.

f. Cryſtallized, from Giſlof in the province of Skone [*a*].

SECT.

[*a*] The ſteel-grained and ſcaly ores are of a dim and dull appearance when they are broken, and their particles have no determinate angular figure: they are therefore in Swediſh commonly called *Blyſchweif*, in oppoſition to the cubical ores, which are called *Blyglanz*.

But, in my opinion, the ores ought to be denominated, and diſtinguiſhed from one another according to their metallic contents. No ore ought, according to the moſt received uſage, to be called *Blyſchweif*, but that which contains only lead and ſulphur.

Moſt part of the ores called *Blyglanz* contain ſilver, even to twenty four ounces per cent. of which we have inſtances in the mines of Salberg, where it has been obſerved that the large diced lead ores are generally the richeſt in ſilver, contrary to what is commonly taught in books; the reaſon of which may perhaps be, that, in making the eſſays on theſe two ores, the coarſe cubical can be choſen purer or freer from the rock, than the fine cubical ores. *The Author.*

The *galena*, *potter's ore*, *bleyglanz*, and *bleyſhweif*, are the commoneſt of all lead ores. They are of a blueiſh dark lead colour, formed of cubes of a moderate ſize, or in cubic grains, whoſe corners appear to have been cut off. Their texture is lamellar, and of a variable hardneſs. The hardeſt ſort contain a large proportion of iron and quartz. Thoſe in grains are the richeſt in ſilver, and contain about 1 or 1,5 *per cent.*

that is, 12 or 18 *ounces* per quintal; the pooreſt, about 60 *grains*. Ores that yield about $\frac{1}{2}$ an ounce of ſilver per quintal, are hardly worth the coſt of extracting it. *See* note [*b*] *to p.* 544.

The proportion of ſulphur to lead in this ore is alſo variable, within the limits of 15 and 25 *per cent.* That which contains the leaſt, is called *bleyſchweif*, and is in ſome degree malleable. The proportion of lead is from 60 to 85 *per cent.* by reaſon of an accidental mixture of quartz; and that of iron is generally very ſmall. It was aſſerted by Monnet, that ſulphurated lead ores are inſoluble in nitrous acid. Watſon affirms, that dilute nitrous acid diſſolves them completely.

The ſpecific gravity of galena is from 7000 to 7780; when it is melted, it yields a yellow ſlag. *The Editor chiefly from* Kirwan.

Galena is found alſo in a *maſſy form* without any regular figure. This kind is very frequent at *Sainte Marie aux Mines.*

Galena, with large *facets*, not forming any regular cryſtals, and quite entirely compoſed of laminæ, is a very common ore.

That in *ſmall facets*, appears like mica, and conſiſts of ſmall, white, and very brilliant ſcales. It is called *white ore of ſilver*, becauſe it contains a great quantity of this metal. Such is that of the mines of Pompean in Brittany.

The galena in *ſmall grains*, mentioned by the author, is very rich in ſilver.

There are few, except that of Carinthia, which are found not to contain ſilver, almoſt all others containing more or leſs.

It deſerves to be noticed, that galenas whoſe facets or grains are the ſmalleſt, yield in general the greateſt quantity of ſilver. It ſeems that the ſilver being in ſome meaſure a body foreign to the combination of *galena*, deranges the regular cryſtallization of this ore. *See Sect.* 278. p. 561 *on the* ſilver-potters-ore.

Galena ſtriated, like antimony, has the external appearance of maſſy galena; but its fracture exhibits flat and brilliant needles, like that ſemi-metal.

Finally, galena, cryſtallized like ſparry lead, in hexagonal priſms, or cylindrical columns, is found in the mines of Huelgoet

SECT. 313. (189.)

3. With ſulphurated iron and ſilver, *Plumbum ferro & argento ſulphurato mineraliſatum* [*a*], is found,

a. Fine-grained.
b. Fine cubical.
c. Coarſe cubical. Theſe are found at Weſterſilfverberget, in Weſtmanland.

When this ore is ſcorified, it yields a black ſlag; whereas the preceding lead ores yield a yellow one.

Huelgoet in Lower Britanny. This is not rich in ſilver, and ſeems to be merely ſome ſparry lead which has been mineralized by ſulphur, without having ſuffered any alteration of form: and indeed there are ſometimes obſerved, upon the ſame piece, cryſtals of pure ſparry lead, intirely covered with a very fine galena, and others which are quite changed into galena, even in the inner part of their priſms. *Fourcroy.*

[*a*] The lead ore, deſcribed by Kirwan, in his Spec. 7. p. 305, as mineralized by *ſulphur* with *ſilver*, and a large portion of *iron*, called *pyritous lead-ore*, ſeems to be the ſame with that deſcribed by our Author in this ſection. Kirwan ſays, that it is nothing elſe but a mixture of galena.

The ore, called *pyriteous lead ore*, is merely a mixture of galena with *brown pyrites*, of which hereafter among the iron-ores. This is of a brown, or yellowiſh-dark colour; of an oblong or ſtalactical form; and of a lamellar, ſtriated, and looſe texture. It contains a large portion of of iron, and affords at moſt 18 or 20 *per cent.* of lead, which flows by barely heating it in the fire, as the iron detains the ſulphur, allowing the lead to run off. *The Editor from* Kirwan.

SECT. 314. (190.)

4. With ſulphurated antimony and ſilver, *Plumbum antimonio et argento ſulphurato mineraliſatum.* Antimoniated or radiated lead ore. This has the colour of a Blyglanz, but is of a radiated texture. It is found,

a. With fine rays or fibres, and,
b. With coarſe rays or fibres.

And is found in Maklos Schacht and Fierde-Bottn, in the mine of Salberg in Weſtmanland. The lead in this ore prevents any uſe being made of the antimony to advantage, and the antimony is likewiſe very injurious in the extracting of the ſilver [*a*].

SECT. 315. (Additional.)

Lead mineralized by Arſenic.

This ore was lately diſcovered in *Siberia*. Externally it is of a pale, and internally of a deep red colour.

[*a*] This lead-ore, when heated, yields a white ſmoke; and affords 40 to 50 *per cent.* of lead, and from ½ to 2 ounces of ſilver in the quintal. *Kirwan.* This is found alſo at St. *Marie aux mines.* Mongez.

For

For the moſt part it is criſtallized into rhomboidal paralellopipedes, or irregular pyramids.

According to Lehman it contains *ſulphur*, *arſenic*, and about 34 *per cent.* of *Lead*. Mr. Pallas ſays that it contains alſo ſome ſilver.

It was found near *Catherineburg* in *Siberia*: and Lehman ſays, that on being reduced to powder, it reſembles the beſt carmine.

Mongez examined ſome, which on the outſide was of a yellow-greeniſh colour; this had been found among quartz in the ſame country, and contained alſo ſome arſenic.

Both theſe varieties may be eaſily reduced by the heat of a blowpipe. *The Editor.*

SECT. 316. (Additional.)

Stony, or Sandy Lead Ores.

This ore conſiſt either of the *calciform*, or of the *galena* kind, intimately mixed, and diffuſed through ſtones and earth, chiefly of the calcareous, or of the barytic genus. *Kirwan.*

Of this ſpecies ſeems to be the earthy lead-ore, falſely called *Native Maſſicot*, found in the lead mines of Pompean in Britany, in the form of ſolid pieces; they are either yellowiſh or grey: appear bright like glaſs when broken: effervesce with acids: whence it appears that this ore is mineralized by the aerial acid, and ſometimes it is mixed with clay. *Mongez.*

SECT.

SECT. 317. (191.)

Observations on Lead Ores.

I know of no native lead; and all that has been ſaid reſpecting it, is liable to conſiderable objections. *(See Sect.* 306.)

Such of the potters ores as do not contain any ſilver are very ſcarce; yet they are often found ſo poor in ſilver, that it does not anſwer the expences of extracting. Theſe, when they are free from mixtures of the rock, are, without any previous fuſion, employed to glaze earthen-ware; and a great trade is carried on in the Mediterranean with ſuch ores, from the lead-mines of Sardinia and France [*a*].

[*a*] 1. In Hungary and Tranſilvania, the lead-ore contains, beſides the ſilver, a conſiderable quantity of gold.

Whether lead be mineralized with more metallic bodies than thoſe already mentioned in the preceding Sections, is as yet unknown. The mine of Morgenſtern, at Freyberg, has a peculiar variety of lead ore, containing ſilver, which deſerves to be noticed on account of its yellowiſh-brown colour; and likewiſe on account of its ſingular figure, which conſiſts of ſlender cylinders. *See note* [*b*] *to p.* 544, *on the* ſilver *generally contained in* lead-ores.

2. Sometimes it is found growing in dendritical forms, like the *knit-cobalt*.

At Goſlar they call a lead ore, mixed with blend, *Brown lead-ore*. Brunnich.

3. Lead

3. Lead unites by fuſion to moſt other metals. A ſmall addition of it makes gold and ſilver brittle; though a proportional addition of either of theſe laſt to lead has the contrary effect, and makes it more ductile. Copper does not unite with lead, unleſs the lead be red-hot and boiling. After this union, it may again be ſeparated by uſing a gentle heat, which melts the lead only, which runs off, and leaves the copper. This mode of ſeparating metals by means of their different degrees of fuſibility, does not ſucceed in various other metallic mixtures when fuſed together.

4. Lead does not unite with iron; but if both are expoſed to the fire in a proper veſſel, the lead is converted into litharge, which attacks and corrodes the iron, by ſeizing its phlogiſton; and afterwards reduces the martial calces into a dark-coloured glaſs.

5. This property, which lead poſſeſſes, of reducing all imperfect metals into a glaſſy ſlag, is the means uſed to purify gold and ſilver, neither of which can be thus deprived of its metallic character, but remains untouched at the bottom of the coppel. This proceſs is the more complete, from the efficacy of glaſs of lead to diſſolve all earthy bodies, it being ſo powerful a flux, that no earthen veſſel or crucible can contain it when fuſed, of whatever materials the veſſel be made. A mixture of raw and burned clay ſtands the action of lead for the longeſt time; but its ſides are alſo at length corroded.

6. Litharge is employed in the compoſition of all the finer glaſſes, called *Paſtes*, which imitate *precious ſtones*. The addition of litharge makes them more ſolid and brilliant; and enables them to diſperſe the different coloured rays in a greater degree. The pureſt flint, purified alkali, borax, and litharge, are the chief and eſſential ingredients; the other additions, chiefly of metallic calces, are made only for the ſake of tinging them of various colours.

7. The white or cryſtalline glaſs, called by the name of *flint-glaſs*, contains a large proportion of lead, which communicates a greater degree of ductility, and a ſort of unctuoſity, which renders it eaſier to be worked and poliſhed, &c. It is the pureſt-calx of lead called *minium*, made immediately from the metal, and the moſt pure *quartzous ſand*, with pure *mineral alkali*, or ſtill better with good *nitre*, that produce, when

when properly melted, the beſt flint-glaſs. The greater the proportion is of *red-lead*, the heavier is the glaſs, and of courſe its refraction is greater; an eſſential requiſite to be employed in forming the compound achromatic object lenſes for aſtronomical purpoſes. It muſt, however, be obſerved, that glaſs made with lead has the defect of being of unequal denſity, for want of a perfect mixture of all its parts; ſo that it is extremely difficult to find pieces of a few inches diameter among hundreds weight of this flint-glaſs, that ſhall be quite free from the filaments and ſtriæ in the inſide of the plate. It was by a great chance that the famous Dollond got once a pot of pure flint glaſs, from which he made the admirable triple object lenſes of three feet and a half foot focus, that are in the hands of various aſtronomers both at home and abroad. But there are already near 20 years that no ſimilar chance has happened again. Many attempts have been made in England and other parts of Europe to remedy this inconvenience; repeated and very conſiderable premiums have been offered to find the method of producing the fitteſt kind of this flint-glaſs for optical inſtruments; but they have not yet ſucceeded according to the public expectation.

8. Lead is of very extenſive uſe, as when employed in ſheets of a proper thinneſs for covering buildings, for making pipes to convey water, ciſterns or reſervoirs for keeping the ſame; to make ſtatues and buſts for the ornament of gardens, for ſecuring iron bars in hard ſtones, and for ſundry kinds of veſſels for evaporation, &c.

9. Sheets of lead are made by paſſing this metal, whilſt cold, between two cylinders, or rollers of iron, by which means their thickneſs is rendered quite uniform, as ſmooth as the rollers themſelves, and of the deſired thinneſs. This is called *milled lead*; but it is harder, and more brittle, than caſt ſheet-lead, which may be ſafely bent in any way without forming any crack. Doubtleſs this is the reaſon why plumbers ſay, that *milled lead*, although it may form a neater and lighter work, will not laſt ſo long. The *caſt ſheets* of lead are made by pouring this metal, when fuſed, upon the top of an inclined flat table, or mould formed with lateral riſing borders. If the ſheets are required to be thin, the bottom is covered with a woollen, and above this a linen cloth, which is not burned nor ſcorched thereby. The melted lead being

being received in a wooden caſe without a bottom, and of the ſame width of the table, this caſe is drawn down over the ſloping bottom by a man at each ſide, and leaves a ſheet, more or leſs thin, according to the degree of the velocity of its deſcent. But for making thicker ſheets of lead, the bottom of the ſaid mould or table is covered with wet ſand, and the fuſed metal is conducted over it by a wooden ſtrike, which bears on the borders of each ſide.

10. Common ſhot is made, by pouring melted lead into an iron box, perforated with ſmall holes in the bottom, through which it runs into a veſſel of water; but as it forms itſelf into a kind of drops, in the ſhape of pears, a ſmall quantity of orpigment, or of white arſenic, is mixed with the metal, by which means it becomes harder, and aſſumes the form of more perfect ſpheres. Thoſe which are not ſufficiently ſo, are ſeparated from the reſt, by making the whole run ſtraight down in an inclined plain, and thoſe which are irregular tumble off at the ſides. After this the ſhot is ſorted, by paſſing through ſieves of different ſizes.

11. Lead expoſed to the air tarniſhes ſo much more eaſily, as the air is more humid: it contracts a white ruſt, which the water gradually carries off. Water in fact alters lead, particularly if charged with ſaline matters. Cauſtic alkaline lixivia, boiled on veſſels of lead, diſſolve a ſmall portion of it, and corrode a conſiderable quantity of the ſame. Even the ſides of the veſſels, for carrying water, are covered with a whitiſh cruſt, which has been examined, and is found to be a true calx of this metal.

12. It has been obſerved, that plants do not thrive ſo well in leaden, as in earthen veſſels.

13. All the phænomena of the calcination of lead, and of its reduction to the metallic ſtate, evidently ſhew that it has the ſmalleſt adheſion to phlogiſton, as appears by the ſimple action of fire, which ſeparates both, whilſt their attraction is equally as quick in its reduction to the metallic ſtate. A common red wafer, which owes its colour to red lead, by being burned in the flame of a candle, immediately exhibits pure globules or little drops of the reduced metal. The curious experiments made lately at Paris, by Doctor Luzuriaga, penſioner of the Court of Spain, give another evident proof of the readineſs with which lead parts with its phlogiſton.

phlogiſton. He put 4 ounces of lead ſhot, wetted with water, into a pint bottle filled with *atmoſpheric air*, and cloſed with ſtopple; he ſhaked it various times; a black powder was produced, which ſoon turned white; at the end of 24 hours, on opening it, inverted in a baſon of water, the air had loſt the fifth part of its bulk, and was quite *phlogiſticated*. The ſame happened with *dephlogiſticated air*; but its bulk was ſtill much more reduced; the contrary happened, however, when the experiment was made with *inflammable air*, which, if it is not *phlogiſton* itſelf, is at leaſt greatly loaded with it. *Journ. de Phyſique* for Oct. 1784, p. 256.

14. The effects of lead on the human body, if internally taken, are very dangerous. Thoſe who are long expoſed to its vapours when melted, even thoſe who grind its *calces*, as *minium*, *ceruſe*, and *litharge*, for painters, are ſubject to violent gripes, and conſtipations of the bowels, contractions of the limbs, and other diſorders. Culinary veſſels, lined with a mixture of tin and lead, which is the uſual tinning, are apt to communicate to acid foods, ſour broths, ſauces, ſyrups, and other alimentary preparations, with juice of lemons, or other vegetable acids, very pernicious qualities, chiefly if they are ſuffered to ſtand long on the veſſels; and the more ſo, if the perſons are of an irritable habit by their bodily conſtitution. At any rate this metal, when received into the ſtomach and inteſtines, even of the moſt robuſt perſons, occaſions violent colics, frequently accompanied with vomiting of green bile, and remarked for the flattening of the belly and depreſſion of the navel. The antimonial emetics and purgatives are uſed in theſe caſes with ſucceſs. Navier recommends the different *livers of ſulphur*, in caſes of perſons poiſoned with *lead*, as well as with *arſenic*, and *corroſive ſublimate*. It is particularly ſucceſsfull in the palſy and tremors, which generally attend thoſe who have laboured under the *Colica Pictonum*. The *Editor*, from *Newman*, *Watſon*, and *Fourcroy*.

15. In Holland, and perhaps in other places, it has been cuſtomary to correct the moſt offenſive expreſſed oils, as that of *rape-ſeed*, and rancid oils of *almonds*, or of *olive*, by impregnating them with lead, which mixture renders them very pernicious to health, if taken internally. This dangerous abuſe may be diſcovered, if ſuſpected, by mixing a little of that oil with a ſolution of *orpigment* made in *lime-*

SECT. 318. (192.)

Copper [a], *Cuprum*, *Æs*, *Venus*.

General Properties of this Metal.

This metal is,

a. Of a red colour.

b. The ſpecific gravity of the Japan copper is 9000, and of the Swediſh 8784 or 8843 to 1000.

It

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water; for, on ſhaking them together, and ſuffering them to reſt, the oil, if it has any ſaturnine tint, will appear of an orange-red-colour; but if pure, it will appear of a pale yellowiſh one.

16. The ſame abuſe has been alſo practiſed with *acid-wines*, which diſſolve ſo much lead, or ſugar of lead, as to acquire a ſweet taſte; but it then becomes a ſlow poiſon to thoſe who drink it. This may, however, be diſcovered in a ſimilar manner; and it is upon the ſame principle that the *liquor probatorius* is made, to aſcertain the fact. This *liquor* is nothing elſe than a ſolution of *orpigment*, or of *liver* of *ſulphur* in *lime-water*. If a few drops of this ſolution be put in a glaſs of the ſuſpected liquor, it will exhibit a precipitation like a cloud of a dark colour. *The Editor from* Fourcroy, Newman, &c.

See the Notes *to p.* 589, *on the pretended power of* fumes of lead *to reduce* quickſilver *into a fixt metal, like* ſilver.

And the note *to p.* 592, *on the imaginary exiſtence of* mercury *in the metallic ſubſtance of* lead.

[*a*] 1. Copper is an imperfect metal, of a peculiar reddiſh-brown colour, and brilliant enough; but it is ſubject to tarniſh: it has a diſagreeable ſmell, perceptible upon friction,

c. It is conſiderably ſoft and tough.

d. The calx of copper being diſſolved by acids becomes green, and by alcalies blue.

e. It is eaſily calcined in the fire into a blackiſh blue ſubſtance, which, when rubbed to a fine powder, is red; when melted together with glaſs, it tinges it firſt reddiſh brown, and afterwards of a tranſparent green or ſea-green colour.

It

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tion, or on being heated; its taſte is ſtyptic and nauſeous, leſs ſenſible, however, than that of iron.

2. It is of a very conſiderable hardneſs, tenacity, ductility, and maleabillity; and its elaſticity is greater than that of any metal, except ſteel.

From this laſt property, maſſes of this metal emit a loud and laſting ſound when ſtruck, and this more eſpecially when of a proper figure; *viz.* if it be ſuch that the metal may vibrate in the ſimpleſt manner poſſible. Thus if it be caſt into the hollow form of a bell, without any cracks or imperfections, an uniform tone will be produced by it; or at leaſt the tones produced by the ſtroke will conſiſt of one predominant tone, and of others that have a muſical agreement with it.

3. It has ſo vaſt a tenacity, that a wire of a tenth of an inch in diameter, is capable of ſupporting 299.5 pounds weight, before it breaks. Copper may be drawn into very fine wire, and beaten into extremely thin plates. The German artiſts, chiefly thoſe of Nurenberg and Auſburg, are ſaid to poſſeſs the beſt method for giving to theſe thin plates of copper, a fine yellow colour like that of gold, by ſimply expoſing them to the fumes or vapours of zinc, without any real mixture of it with the metal. Theſe plates are cut into proper ſizes; then are beaten as thin as leaf of gold; and put likewiſe into books of paper, which are ſold all over Europe, in large quantities, and at a very low price, for the vulgar kinds of gilding.

The

f. It diſſolves in all the acids; *viz.* The acids of vitriol, ſea-ſalt, nitre, and the vegetable; and likewiſe in all alcaline ſolutions. That it becomes ruſty, and tarniſhes in the air (a conſequence of a ſolution having preceeded) depends very much on ſome vitriolic acid which is left in the copper in the refining.

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4. The parings, or ſhreds of theſe very thin leaves of yellow copper, being well ground on a marble plate, are reduced to a powder ſimilar to gold, which ſerves to cover, by means of ſome gum-water, or other adheſive fluid, the ſurface of various mouldings or other pieces of curious workmanſhip, giving them the appearance of real bronze, and even of fine gold, at a very trifling expence; becauſe the gold-colour of this metallic powder may be eaſily raiſed and improved, by ſtirring it on a wide earthen baſon, over a ſlow fire.

5. In ſome of its ſtates, copper is as difficultly extended under the hammer as iron; but proves ſofter to the file; and never can be made hard enough to ſtrike a ſpark with flint or other ſtones, from whence proceeds the uſe that is made of this metal for *chiſels*, *hammers*, *hoops*, &c. in the gun-powder works.

6. When this metal is broken, by often bending it backwards and forwards, it appears internally, of a dull red colour without any brightneſs, and of a fine granulated texture; not ill reſembling, as Cramer obſerves, ſome kinds of earthen-ware.

7. Copper continues malleable in a red heat, and in this ſtate extends much more eaſily than when cold; but it wants that valuable quality of iron, of cohering together, ſo as to weld, or join together two pieces of it into one, though equally heated.

8. At a degree of heat far below ignition, the ſurface of a piece of poliſhed copper becomes covered with various ranges of priſmatic colours, the red of each order being neareſt to the end, which has been moſt heated.

refining. This metal is more eaſily diſſolved when in form of a calx than in a metallic ſtate, eſpecially by the acids of vitriol and ſea-ſalt, and the vegetable acid.

g. Vitriol of copper is of a deep blue colour; but the vegetable acid produces with copper a green ſalt, which is called *verdigriſe*.

It

This laſt effect, proceeds from the beginning of the calcination on the outer ſurface, the calx being thicker where the heat has been greater, and decreaſing thinner and thinner towards the cold part. This explanation coincides with the appearance of that ſucceſſion of coloured rays formed round the point of contact, between a convex and a plane ſurface of tranſparent glaſs; where the red colour is ſeen, in each ſet, towards the thicker angular ſpace that ſtands between them.

9. This metal reduced into a fine powder, or copper-filings, if thrown acroſs the flame, give *blue* and *green* colours. On account of this property, they are uſed in fire-works.

10. When the melted copper produces a flame tinged of a *green*, *blueiſh*, or *rainbow-colours*, it is a mark that the metal burns, and begins to ſcorify. The heat continuing to increaſe, the calcination proceeds more rapidly; and powdery ſcales are formed on its ſurface, which may be eaſily rubbed off. This powdery ſcoria, or calx, cannot be reduced in the greateſt heat of common furnaces; but on being expoſed to the focus of a good burning lens, the ſolar rays melt it into a *deep red*, and almoſt *opake glaſs*.

11. Copper melts in a ſtrong white heat, rather leſs than what is required to melt gold or ſilver; as may be ſeen in the table at page 230; although various metallurgiſts ſay, that this melting heat is ſuperior to that required for fuſing theſe two noble metals.

When melted, if afterwards it is left to cool very ſlowly, it forms itſelf into pyramidal cryſtals, which are ſometimes

ſolid,

h. It may be precipitated from its ſolutions in a metallic ſtate; and this is the origin of the precipitated copper of the mines, called Ziment copper. *See Sect.* 320.

k. It is not eaſily amalgamated with quick-ſilver; but requires for this purpoſe a very ſtrong

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ſolid, and ſometimes compoſed of ſmaller ones, adhering ſideways to one another.

12. When copper is in a liquid ſtate, it is remarkably impatient of moiſture. The contact of a little water occaſions the metal to explode, throwing itſelf about with the utmoſt violence, to the great danger of the by-ſtanders. There is the ſame danger in melted braſs, or bell-metal, or any other mixture, whereof copper makes a part; ſo that founders of all ſorts ſhould be equally cautious in this reſpect. Cramer recites a melancholy accident of this kind, which happened at the braſs-foundery in *Windmill-hill*, near *Moorfields*, *London*, about 20 years before the time he wrote his work; when ſeveral people of quality were invited to ſee the caſting of two large-braſs-cannon at a time. The heat of the metal of the firſt-gun, drove ſo much damp into the mould of the ſecond, which was near it, that as ſoon as the metal was let in, it blew up with the greateſt violence, tearing up the ground ſome feet deep, breaking down the furnace, untiling the houſe, killing many of the ſpectators on the ſpot with the ſtreams of melted metal, and ſcalding many others in a moſt miſerable manner. Copper may, nevertheleſs, be granulated like other metals, by cautiouſly pouring a very little at a time into water, as will be mentioned in the *note* [*e*] to *Section* 332.

13. The *vitriolic acid* does not act on copper, unleſs concentrated and boiling: during this ſolution a great quantity of ſulphureous gas flies off; afterwards a brown thickiſh matter is found, which contains the calx of the metal, partly combined with the acid. By ſolution and filtration, a blue ſolution is obtained, which being evaporated to a certain degree, produces, after cooling, long rhombodial cryſtals, of

ſtrong trituration, or the admixture of the acid of nitre.

k. It becomes yellow when mixed with zink, which has a ſtrong attraction to it, and makes braſs, pinchbeck, &c. *See Sect.* 332 *Note* [*e*].

It

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a beautiful *blue* colour, called *vitriol of copper*; but if this ſolution be merely expoſed a long time to the air, it affords cryſtals, and a *green calx* is precipitated, a colour which all calces of this metal aſſume, when dried by the air.

14. *Blue vitriol*, however, is ſeldom formed by diſſolving the metal directly in the vitriolic acid. That ſold in the ſhops is moſtly obtained from *copper pyrites*. It may alſo be made by ſtratifying copper-plates with ſulphur, and cementing them together for ſome time; becauſe the vitriolic acid of the ſulphur, being diſengaged, attacks and corrodes the metal, forming a metallic ſalt, which, by affuſion of water, yields perfect cryſtals of *blue vitriol*. This ſalt has a very ſtrong ſtyptic taſte, approaching to cauſticity. It fuſes in the fire, loſes its water of cryſtallization, and becomes of a bluiſh-white colour: it requires a much ſtronger heat to ſeparate the vitriolic acid, which adheres more ſtrongly to copper in this ſalt, than to iron in the *green vitriol*.

15. The *nitrous acid*, on the contrary, diſſolves copper, when cold, with great rapidity; and a great quantity of ſmoking air, or gas, flies off, which, on being received in a pneumatic apparatus, and mixed in a glaſs-tube, with atmoſpheric air, ſhews its good or bad quality for the reſpiration of living animals, accordingly as the common bulk is more or leſs diminiſhed. This is one of the moſt important diſcoveries made by the great philoſopher Dr. Prieſtley. Various inſtruments known by the name of *Eudiometers*, have been ſince invented for making theſe experiments with eaſe and ſatisfaction, if properly managed. The more the bulk of the two airs is diminiſhed, the better the atmoſpheric air is for animal reſpiration; on the contrary, the worſt air

is

l. It is eaſily diſſolved by the glaſs of lead, which is coloured green by it.

m. When this metal is expoſed to the fire, it gives a green colour to the flame in the moment it begins to melt, and continues to do ſo afterwards, without loſing any thing conſiderable of its weight.

It

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is that, which diminiſhes the leaſt after its being mixed with the *nitrous air*.

16. This nitrous ſolution of copper is of a greeniſh-blue, although Fourcroy calls it a *deeper* blue than that by the vitriolic acid. If evaporated with precaution, it cryſtallizes by cooling; and produces elongated parallelograms; if the evaporation be quickly performed, the priſms are hexaedral, and reſemble bundles of diverging needles; but by a ſtrong and quick evaporation only, an irregular maſs is produced. This ſalt has a cauſtic taſte, and is applied to corrode excreſcences on the ſkin: it detonates, though not ſtrongly, over burning coals. When it is dry, if it be placed in a heat not much greater than the hand can bear, it takes fire. A ſmall quantity of this ſalt, being put in a piece of tin-foil, wetted with a few drops of water, and inſtantly wraped up, the two ends being folded cloſe, in a few ſeconds produces a great heat, emits ſtrong nitrous vapours: and a deflagration takes place, burſting with a crackling noiſe, and throwing out ſparkles of fire, after which a grey calx remains behind, as has been already deſcribed in the note N° 8. to page 639.

17. The *marine acid* diſſolves copper only when concentrated and boiling; it aſſumes a deep green, almoſt approaching to a *brown* colour. This combination produces a maſs very ſoluble in water; this laſt becomes of a fine *green* colour, which diſtinguiſhes it from the two preceeding ſolutions by the vitriolic and nitrous acid. This marine ſalt of copper is of an agreeable graſs-green colour, is cauſtic, and of a very aſtringent taſte. The air, or gas, that is produced by the

n. It requires a ſtrong degree of heat before it melts, though leſs than iron.

SECT. 319. (193.)

Native Copper, *Cuprum Nativum.*

Copper is found in the earth,

A. Native, or in a metallic ſtate; Virgin or native copper, *Cuprum nativum.*

1. Solid, *Solidum*, is found in the iron mine of Heſslekulla, in the province of Nerike, and at Sunnerſkog, in the province of Smoland; alſo in the Ruſſian Carelia, and in other foreign places [*a*].

Friable

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action of marine acid on copper, has not been well examined, as Fourcroy remarks; it ſeems, however, to be of the inflammable kind. Vegetable acids, alkalies, and oily or fat ſubſtances, act alſo on copper. The dangerous conſequences of theſe ſolutions will be mentioned in Sect. 332."

18. Copper grows *black* or *brown* by long expoſure to the air, which acts upon it the more eaſily when it is moiſt or altered; and forms upon its ſurface a *green* ruſt or calx, which ſeems of a ſaline nature; ſince it has taſte, and is diſſolved by water. But this ruſt only attacks the ſurface of the metal, and even ſerves to its preſervation, as we may learn from the antient medals and ſtatues, which are well preſerved under this coat or ruſt which covers them. The antiquaries call this *cruſt* by the name of *patine*; and value it greatly, as a mark of the great antiquity of the pieces covered therewith. *The Editor from* Kirwan, Nicholſon, Fourcroy, Newmann, &c. *See the* notes *to* Sect. 332. *concerning the* uſes *of copper, and its* poiſonous *qualities, when taken internally.*

[*a*] 1. Native copper, *viz.* copper in a more or leſs malleable ſtate, and either of its own peculiar, or of a grey

or

2. Friable in form of ſmall, and ſomewhat coherent grains, *Cuprum nativum particulis conglomeratis diſtinctis.* Precipitated or Ziment Copper. It is found at Riddarſhyttan in Weſtmanland, at Fahlun in Dalarne, and in Hungary.

It has been obſerved, that both copper and the vitreous ſilver ores after ſettling from water, are looſe, or in grains; but that they in time grow

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or blackiſh colour, has been found either in *grains*, or in large ſhapeleſs *ſolid lumps*, or in a *foliated*, *capillary*, *arboreſcent* form; or *cryſtallized* in quadrangular pyramides, on clay, ſhiſtus, quartz, fluors, zeolytes, &c. in *Siberia*, *Sweden*, *Germany*, *Hungary*, *Tranſylvania*, *&c.*

2. It undoubtedly has ſometimes been produced from precipitation by *iron*, from water in which it was held in ſolution; and this is the pureſt ſort. But in many caſes it could not have been produced in that manner; and then this ſort is never very pure, but mixed either with *gold*, *ſilver*, *iron*, or with *ſulphur*: This laſt combination forms what is called *black copper*. Kirwan.

3. Native copper is found in very conſiderable quantities at *Cape Lizard* in Cornwall: it is formed into threads or branches, and veins of ſome thickneſs, contained in blackiſh ſerpentine mixed with browniſh red, and covered externally with a greeniſh nephrites, partly adherent to it, and partly looſe. In the ſame rocks alſo, native copper has been found in large lumps.

4. But a more conſiderable quantity of *native copper* is found at *Huel-virgin* in the ſame province; it ſhoots into various branches, and in various directions; they ſeem to be formed of ſmall rhomboidal cryſtals, interſperſed with quartz, of which the impreſſions are to be ſeen in the copper itſelf; from whence it might be concluded the prior exiſtence of the quartz before the formation of the metal. Some of theſe lumps of native copper have been found in this ſpot that

grow ſolid and ductile: whence the diſpute about the diſtinction between *native* and *precipitated* copper may ceaſe, the rather as *native* copper will ſcarcely be found in other places, and in any other kinds of ſtones, than thoſe through which the ziment or vitriolic waters have circulated; although the fiſſures through which it has run, may afterwards be filled with a ſtony ſubſtance.

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weighed from 20 to 30 pounds; and only in the month of March 1785, there were extracted from this mine no leſs than 1400 tons, *viz.* 2800000 pounds weight of rich copper ore.

5. At the place called *Carrarach*, which is contiguous to *Huel-virgin*, and which is not a leſs rich mine, ſome cryſtallized native copper was found, with the tranſparent vitreous copper ore, of a ruby colour, cryſtallized in octahedrons; but this fine red-cryſtallized vitreous copper ore begins to be very ſcarce there.

6. Near the copper vein at Carrarach, is found alſo a compact native copper, of a ſpherical form, in lumps; the copper, either is ſtill in its metallic form; or is beginning to be transformed into red copper-glaſs, imbedded in decayed granite.

7. Native copper, of a tender and moſs-like form, united to vitreous ruby copper-ore, cryſtalized in rhombs, is found in the clefts of the mountains compoſed of killas, near Poldry. *The Editor from* M. H. Klaproth's *Obſervations on ores of Cornwall.*

8. An indurated iron-clay has lately been found under the ſurface of the ſea, in the Faroe Iſles, in which there is ſcattered a zeolite, with *native copper*. Brunnich.

SECT.

SECT. 320. (194.)

Calciform Ores of Copper.

B. In form of a calx, *Minera cupri calciformis.*
1. Pure, *Minera cupri calciformis pura.*
a. Looſe or friable, *Ochra veneris.*
1. Blue, *Cæruleum montanum* [*a*].

Is

[*a*] 1. This, and the two following ores of copper, are mineralized by the aerial acid; they are ſoluble in acids, and blacken in a moderate heat. The firſt is called *mountain-blue*, though ſome call it by the name of *Chryſocolla*, and the Hungarians give it the name of *lapis lazuli*; but this laſt is a true zeolyte, whoſe blue colour proceeds from iron, as has been obſerved already in Sect. 139, and p. 248.

2. The *Mountain Blue* frequently appears in a *looſe form*, but ſometimes it is *indurated*, and even cryſtallized: it is then mixed with quartz. 100 parts of it contain about 69 of *copper*, 29 of *aerial acid*, and 2 of *water*. Mr. Morveau has ſhewn that the calces of copper are determined rather to a *blue*, than to a *green colour*, by a greater proportion of phlogiſton. The *Editor from* Kirwan.

3. The *azure* copper ore is alſo met with on quartz at the mines of *Huel-virgin*, and at *Carrarach* in Cornwall, according to *Klaproth's obſervations*.

4. Another *Cæruleum montanum*, leſs pure than the above, will be mentioned in Sect. 322.

We may obſerve in general, that the copper ores, after roaſting, communicate a *blue colour* to volatil aklali, by digeſtion. Before roaſting, it is poſſible that the mixture of a portion of arſenic, or even ſulphur, in a ſufficient quantity, may prevent this effect. *Kirwan.*

1. This

Is very ſeldom found perfectly free from a calcareous matter.

2. Green, *Viride montanum.*

Both theſe colours depend on menſtrua, which are often edulcorated or waſhed away [*b*].

3. Red [*c*]. This is an efflorescence of the glaſs copper ore. It is found in the province

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[*b*] 1. This ore is commonly called *Malachite* when in a ſolid form. It has the appearance of green jaſper; but is not ſo hard, ſince it does not ſtrike fire with ſteel. It is either of a radiated or uniform texture, generally of an oval form, and of the ſize of an egg; but ſometimes it is formed of capillary filaments, like ſattin, and ſhews a kind of concentric ſtripes, or ſhreds of paler colours, when cut and poliſhed; its external appearance is like a thick ſhell, with various protuberances of a mamillary form. The ſilky-green copper-ore of this kind from China, in the form of ſolid bundles, is the pureſt. It is found alſo in great quantity on the Voſges, mountains ſo called in Lorraine, and in the mines of the Hartz in Saxony.

2. According to Kirwan, the pureſt malachite contains 75 parts of *copper*, and 25 of *aerial acid*. Its ſpecific gravity, according to *Muſſchenbroeck*, is from 3,500 to 3,994. It is ſometimes mixed with calcareous earth and gypſum; and is found in *Norway* and *Siberia*, &c. Kirwan.

3. Compact *green copper* ore, like malachite, mixed with grey copper-ore; and likewiſe *green-velvet-like* copper, in the form of bunches, is found at Huel-Virgin, in Cornwall. At Carrarach, in the ſame county, is found alſo an amorphous green copper-ore, on a decayed granit; and at St. Menan, the ſame is found ſtratified betwixt quartz, and covered with a browniſh iron. *The Editor from* M. H. Klaproth.

[*c*] 1. This red-ore is the *Minera hepatica*, or the *Leberertz* of the Germans: it is found ſometimes in a looſe form, and is then called *copper-ochre*: but generally it is moderately hard, yet brittle: ſometimes is cryſtallized and tranſparent,

either

of Dal, and at Oſtanberg, in the province of Dalarne.

SECT. 321. (195.)

Red Copper-ore.

b. Indurated, *Indurata.*

a. Red, *Minera cupri calciformis pura & indurata, colore rubro.*

This is ſometimes as red as ſealing-wax, and ſometimes more of a liver-brown colour. It is found in Sandbacken, or Norberg in Weſtmanland, at Ordal in Norway, in Siberia and in Suabia in Germany.

This ore is always found together with native copper, which ſeems to have loſt its phlogiſton by efflorеſcence, and to be changed into this form. It is likewiſe found with the ſulphurated copper, called *Glaſs copper ore.*

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either of a capillary appearance, or in *cubes*, *priſms*, or *pyramids*. It is found in *England*, *Scotland*, *Germany*, &c.

2. This ore contains 73 parts of *copper*, 26 of *aerial-acid*, and 1 of water; and effervеſces with acids.

3. The *brown*, or *hepatic* ore of this kind, contains a variable proportion of *iron*, or *pyrites*, and ſometimes *ſulphurated iron*: and affords from 20 to 50 *per cent.* of copper.

4. It is ſometimes irideſcent in its colour, like the *cat's eye*, or the pſeudopalus of Sect. 95. *The Editor chiefly from* Kirwan.

SECT.

SECT. 322. (196.)

Calciform Copper-ore, impure.

2. Mixed, *Minera cupri calciformis impura*
a. Looſe or friable, *Ochra veneris friabilis impura.*
1. Mixed with a calcareous ſubſtance, *Ochra veneris terrâ calcareâ mixta* [*a*]. *Cæruleum montanum.* In this ſtate copper-blue is moſtly found. It efferveſces during the ſolution in aqua fortis. *See Sect.* 40. (34.)
2. Mixed with iron. Black. It is the decompoſition of the Fahlun copper ore, *Sect.* 198. *a.* of the Author [*b*].

Indurated,

[*a*] In Saalfeld they find alſo a ſort of *green*, ſomewhat indurated calcareous ſubſtance, containing copper; this, when broken, looks fat, and ſomewhat ſhining; but upon the whole, it reſembles a jaſper. It is there very wrongly called a *Green Copper Glaſs-ore.* They make good copper of it. With a phlogiſtic ſubſtance, without being uſtulated, it forms a fit maſs for bells, or a kind of bell-metal. *Brunnich.*

[*b*] By the *fahlun copper ore*, is meant the copper ore of a *fallow* or *fallow* colour. *Lewis.*

In ſome parts, among the native copper-ores from Poldory and Huel-virgin, is found a calciform-copper-ore, ſometimes in a looſe form, covering them like ſand; and ſome times this forms a compact ſtructure, which adheres ſtrongly to them. The former

b. Indurated, *Minera cupri calciformis impura indurata.*

1. Mixed with gypſum, or plaſter. Green. Is found at Ordal in Norway, and there called Malachites.
2. Mixed with quartz. Red. From Sunnerſkog, in the province of Smoland. *Sect* 91. (53.) *B.*
3. Mixed with lime. Blue. This is the *lapis armenus*, according to the accounts given of it by Authors [*c*].

SECT. 323. (Additional.)

The Cupreous Stones.

Analogous to the calciform copper ores, are the *lapis Armenus*, of which was already ſpoken in Sect. 41. p. 61: and in the note [*c*] to the preceeding Section 322. This is very different from the *lapis lazuli*, deſcribed in

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former kind is generally black; and the latter is of a browniſh red, often approaching to the metallic ſplendor of copper. *The Editor from* M. H. Klaproth's *Obſervations on the Foſſils of Cornwall.*

[*c*] The *Lapis Armenus* is a blue ſtone, which does not admit of a poliſh, and conſiſts of calcareous earth, or gypſum, penetrated with the blue calx of copper; hence it ſometimes effervesces with acids, and ſometimes not; but never gives fire with ſteel. It loſes its colour, when well heated in the fire. *See Sect.* 41 (35) *pag.* 60. The Editor *from* Kirwan.

Sect.

Sect. 139. p. 247. among the zeolytes; ſince this laſt contains no copper, as may be ſeen in the *notes* to the ſame Section.

The other cupreous ſtone is the *Turquoiſe*; and ſeems to be the tooth of an animal, penetrated with the blue calx of copper. It loſes its colour when over-heated. It is opake, of a lamellar texture, and ſuſceptible of a fine poliſh.

Its ſpecific gravity is from 2,5 to 2,908. Some are of a deep blue, ſome of a whitiſh-blue, but become of a deeper when heated. Theſe ſtones are found in *Perſia* and in *Turkey*, from whence they received their name. But they are alſo found in Lower Languedoc, in France, near the village Simore, where theſe ſtones, when dug out from the mine, reſemble different *bones*, *teeth*, &c. of various ſizes; and are either *whitiſh*, *grey*, or *yellowiſh*. They receive the blue colour, on being ſlowly heated to a high degree; but if the fire be long continued afterwards, the colour is irrecoverably loſt.

Jewellers divide this kind of ſtones, or rather bony ſubſtances, according to their fanciful method into *oriental* and *occidental* turquoiſes; ranging the hardeſt and the fineſt coloured under the firſt epithet, and the ſofteſt, or of an inferior colour, under the *ſecond* denomination. But although experience ſhows the fallacy of ſuch diſtinctions in a great many inſtances, the old cuſtom nevertheleſs continues to prevail.

According

According to Kirwan the blue coppery tincture of the turquoiſes may be extracted from them by diſtilled vinegar: and Reaumur aſſerts, that nitrous acid will not diſſolve the Perſian turquoiſes, though it will thoſe of France; which, if true, indicates a real difference between them. *The Editor from* Kirwan, Neumann, Bomare, &c.

SECT. 324. (197.)

Copper mineralized by Sulphur.

C. Diſſolved and mineraliſed, *Cuprum mineraliſatum.*

1. With ſulphur alone, *Cuprum ſulphure mineraliſatum.* Grey copper ore. It is improperly called *Glaſs copper ore.*

a. Solid, without any certain texture, *Minera cupri ſulphurata ſolida, texturâ indeterminatâ.* This is very ſoft, ſo that it can be cut with a knife, almoſt as eaſily as black lead [*a*].

Fine

[*a*] 1. According to Kirwan, this is the true *vitreous*, or *glaſs-copper ore*, the *kupfer glaſs ertz* of the Germans.

The colour of this ore is *red*, *brown*, *blue*, or *violet*. It is generally ſo ſoft, as to be cut with a knife; and as to its form, it is ſometimes cryſtallized in regular forms, and ſometimes it is amorphous.

This ore is much more fuſible than pure copper. Its ſpecific gravity is from 4,810 to 5,338, and is found in the mines

b. Fine cubical, *Minera cupri ſulphurata teſſulis conſtans minoribus.*

Both theſe varieties are found at Sunnerſkog, in Smoland; where the laſt is ſometimes found decompoſed, or weathered, and changed into a deep *mountain-blue.* See Sect. 320. (194.)

SECT.

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mines of other copper-ores, and in lime-ſtone, ſpar, quartz, mica, and clay.

It is the richeſt of all copper-ores; and affords from 80 to 90 *per cent.* of copper, and 10 or 12 of ſulphur. According to Bergman, it generally contains ſome alloy of iron. The pooreſt red ores of this ſort, are thoſe which contain moſt iron. *The Editor chiefly from* Kirwan.

2. There is a great variety of ſulphurated copper-ores in the mines of Cornwall. A whitiſh grey copper-ore, cryſtallized in ſmall triangular and quandrangular pyramids, with truncated points, is found along with the ſolid copper ore at Poldice and Dolcoth. But the richeſt are the *ſolid grey* ones from Treſeavean, Retallack, Cook-Kitchen, Carrarach, Well-Virgin, and Redruth. Some of theſe may be cut with a knife, like the ſoft vitreous ſilver-ore, particularly thoſe from Treſeavean.

3. Yellow copper-ores of the kind are found at Poldice, Hallamanning, and Dol-coth. The moſt remarkable of them is the ſtalactitical ore, of an hemiſpherical form, called *Run-yellow copper*, found in the mine near Dolcoth, which is 160 yards deep, though elevated more than 60 yards above the level of the ſea. This ore is often variegated with the colours of blue ſteel, or red copper.

4. A compact red vitreous copper-ore, covered with mountain-green, or green copper, and with calciform copper of a vermillion-red colour, is found in cryſtallized quartz, mixed with tender green mica, in the mine at Kaſtle Adit.

5. A new kind of an *olive green coloured* copper-ore, which is arſenical, and is cryſtallized into tender ſpiculæ, of about three

SECT. 325. (198.)

Pyritous Copper-ores.

2. With ſulphurated iron, *Minera cupri pyritacea.* Yellow copper ore. Marcaſitical copper ore, *Pyrites cupri.*

This is various both in regard to colour, and the different proportion of each of the contained metals; for inſtance;

a. Blackiſh grey, inclining a little to yellow, *Pyrites cupri griſeus.* The Fahl cupfer ertz *of the Germans.*

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three lines long, ſtanding ſtraight up, either ſingle, or faſciculated and radiated, was found alſo on the granitical mountain at Carrarach. When tried by the blow-pipe, theſe cryſtals deflagrate with an arſenical ſmoke, and afterwards fuſe, forming a button of a grey colour, which on being melted again with borax, ſoon produces a button of a very pure copper.

Beſides this new arſenical ore, M. H. Klaproth, from whoſe *Mineralogical Obſervations on the mines of Cornwall* theſe two articles are taken, mentions another kind of arſenical copper-cryſtals, which are very ſmall, and aggregated in the form of green cubes, with ſmooth and ſhining ſurfaces, upon grey copper ore, in a maſs of cryſtallized compact quartz, with various cavities in itſelf. Theſe might be eaſily taken for ſmall cubes of fluor; but their conſtituent parts are really nothing elſe but copper and arſenic. *The Editor from* Klaproth's *Obſervations* on the *Mines of Cornwall.*

When decayed or weathered, it is of a black colour; is the richeſt of all the varieties of this kind of copper ore, yielding between 50 and 60 per cent. and is found in Spain and Germany.

b. Reddiſh yellow, or liver brown, with a blue coat on the ſurface, *Minera cupri lazurea* [*a*].

This ore yields between 40 and 50 per cent. of copper, and is commonly ſaid to be blue, though it is as red, when freſh broke, as a rich copper regulus.

c. Yellowiſh green, *Pyrites cupri flavo virideſcens* [*b*].

This is the moſt common in the north part of Europe; and is, in regard to its texture, found

1. Solid, and of a ſhining texture, from Oſtanberg, in the province of Dalarne.

[*a*] This ore is mineralized by ſulphur, with a conſiderable portion of iron, and is called *kupfer lazur*, and *kupfer malm*, by the Germans.

Its colour conſiſts in various ſhades of *blue* and of *reddiſh blue*.

It is of an hard conſiſtence, but brittle.

Contains from 40 to 60 *per cent.* of copper; from 20 to 30 of iron; and the remainder is ſulphur.

The poorer it is in iron, the richer in copper.

This has been confounded by many with the indurated *Mountain blue* of Sect. 322. *The Editor chiefly from* Kirwan.

[*b*] This ore preſents fragments in its fracture; its ſpecific gravity is 4,160; contains more ſulphur; and from 15 to 30 *per. cent.* of copper. *Kirwan.*

2. Steel-

2. Steel-grained, dull in the fracture, from the ſame place, and Falun in Dalarne.
3. Coarſe-grained, is of an uneven and ſhining texture. It occurs in moſt of the Swediſh and Norwegian copper mines.
4. Cryſtalliſed marcaſitical copper ore.

a. Of long octaedral cryſtals [*c*].

This is found at Hevaſſwik, in the province of Dal, and in Loviſagrufva, in Weſtmanland; notwithſtanding its exiſtence is denied by Henckel, and his followers.

d. Pale yellow, *Pyrites cupri pallidè flavus* [*d*].

This cannot be deſcribed but as a ſulphur pyrites, though an experienced eye will eaſily diſcover ſome difference between them. It is found at Tunaberg, in the province of Sodermanland, and yields 22 per cent. of copper.

e. Liver-coloured.

This is found at Falun, in Dalarne, where it contains copper; though at moſt other places where it occurs it does not contain any copper, but is only a martial marcaſite.

[*c*] This cryſtallized ſort is the pooreſt in copper, it contains only from 4 to 8 *per cent.* the remainder is chiefly iron: it is generally reddiſh, and is in fact a martial pyrites, with a ſmall portion of copper. *Kirwan.*

[*d*] The pure yellow contains moſt copper; namely from 20 to 30 *per cent.* its texture is foliated. Theſe pyritous ores always contain ſome *argillaceous* earth, and a little of the *ſiliceous.* Kirwan.

SECT. 326. (Additional.)

Pyritous Copper, with Silver and Arſenic.

With ſulphurated ſilver, arſenic, and ſome iron. *Cuprum argento ſulphurato, arſenicò et ferro mineraliſatum.* Fallow copper-ore.

In Hungary it is called *Black Copper-ore.*

It contains only a few ounces of *ſilver.*

This ore is found in Hungary and Germany [*a*]. Theſe ores yield a brittle copper regulus.

[*a*] The following natural mixtures of copper-ores, with other metals, have been already mentioned in the preceding ſections, *viz.*

Copper with gold pyrites. *See Sect.* 263. *p.* 527. Note [*d*] N°. 6.
with gold and ſilver, &c. *See Sect.* 265. *p.* 544. No. 2 and 3.
with ſilver and iron, &c. *See Sect.* 272. *p.* 554.
with ſilver and antimony, &c. *See Sect.* 276. *p.* 559.
with mercury, &c. *See Sect.* 294. *p.* 601. The Editor.

SECT.

SECT. 327. (199.)

Pyritous Copper, with Arſenic, or White Copper-ore.

3. With ſulphurated arſenic and iron, *Cuprum ferro et arſenico ſulphurato mineraliſatum.* White copper-ore [*a*].

[*a*] 1. This copper-ore, is called *arſenical*, or *grey copper ore*. *Kupfer Fahlertz*, or *Weiſs Kupferertz*, by the Germans.

It is of a *white*, *grey*, or *brown* colour; is moderately hard and very brittle.

Sometimes it is cryſtallized, but often of an indeterminate figure. It is of a very difficult fuſion, and pretty heavy.

It contains from 35 to 60 *per cent.* of copper. The *brown* is the richeſt in copper; the *white* or *grey* contains moſt arſenic.

It frequently contains ſilver. If it exceeds 1 or 2 *per cent.* it is then called *grey ſilver ore.*

It is found embodied in all ſorts of ſtones, and mixed with other copper-ores, as well as with the ores of all other metals. *Kirwan*, p. 266.

This kind of copper-ore is found alſo in the copper and tin-mines of St. Ives in Cornwall, according to the account given by Mr. Raſpe; and the Chev. Born mentions the ſame ore found in Hungary. *The Editor.*

N. B. To aſſay theſe ores in the dry way, they ſhould firſt be pulveriſed and ſeparated, as much as poſſible, from ſtony and earthy particles; then roaſted, to ſeparate the ſulphur and arſenic; then melted with an equal weight of *Mr. Tillet's flux*, which conſiſts of two parts of *pounded glaſs*, one of calcined *borax*, and $\frac{1}{8}$ of *charcoal*. If the ore be poor, more borax may be added. Black flux is hurtful, as it forms an *hepar*, which holds part of the copper in ſolution. *Kirwan*, p. 267.

It is ſaid to be found in the Hartz, in Germany, and to reſemble an arſenical pyrites; but I have never met with this kind.

However, moſt of the pyritous copper ores, as well as the ſulphur pyrites, contain a little arſenic, though it is in too ſmall a quantity to be worth notice.

SECT. 328. (Additional.)

Pyritous Copper, with Arſenic and Zinc.

According to Mr. Monnet, this ore is found at *Catharineberg* in *Bohemia*.

It is of a brown colour; of a hard, ſolid, and compact granular texture.

It contains from 18 to 30 *per cent.* of copper [*a*].

[*a*] 1. It is analyſed in the liquid way, by ſolution in *nitrous* acid, and precipitation of the copper by iron.

2. The iron and zinc are precipitated by the *Pruſſian alkali*.

3. The precipitate is calcined and rediſſolved in nitrous acid, which ſolution is evaporated to dryneſs.

4. The iron being thus dephlogiſticated, becomes inſoluble in nitrous acid.

5. The calx of zinc, on the contrary, is rediſſolved in that acid, and again precipitated by the *Pruſſian alkali*.

6. 100 *gr.* of this precipitate, waſhed and dried, are equivalent to 20 of zinc in its metallic ſtate; and 100 *gr.* of dephlogiſticated iron are equivalent to 73,5 of iron in its metallic ſtate. *Kirwan*, p. 268.

SECT.

SECT. 329. (200.)

4. Diſſolved by the vitriolic acid, *Cuprum acido vitrioli ſolutum: Vitriolum Veneris* [*a*]. See Sect. 205. (122.2)

SECT.

[*a*] 1. In the year 1673, our countryman, Dr. Brown, viſited a famous copper-mine at *Herr-grundt*, about ſeven Engliſh mines from Newſol, in the *Upper Hungary*; and he informs us that there he ſaw two ſprings, called the *Old*, and *New ziment*, which turned iron to copper, as it is vulgarly ſaid. But the caſe is, that the *iron* is diſſolved by the *vitriolic acid* of this ſpring-water, and the *copper* is precipitated, in its metallic form, in the place of the *iron*. It has been the cuſtom in Germany, for ſome centuries, to collect the copper contained in theſe waters, by filling with them ſome pits made purpoſely for this operation. Old iron is thrown in, and being diſſolved by the acid, is ſuſpended in the water, whilſt the copper is precipitated: the mud being raked out, is melted afterwards in a furnace, and a very fine copper is produced: from *one hundred* tons of iron, 84, and ſometimes 90 tons of fine copper is thus produced.

2. But although this method of obtaining copper has been long practiſed in Germany, yet it is but of late years, ſays Bp. Watſon (p. 238 of the firſt volume of his Eſſays), that any ſucceſsful attempts of this kind have been made either in *England* or *Ireland*. In this laſt at leaſt, it was quite owing to an accident. There are the very celebrated copper-mines at *Arklow*, in the county of *Wicklow*, in Ireland; and from theſe mines, iſſues a great quantity of water, ſtrongly impregnated with *vitriol* of *copper*. One of the workmen having accidentally left an *iron ſhovel* in this water, he found it, ſome weeks after, ſo incruſted with a coat of copper, that it was thought to be changed into copper.

SECT. 330. (Additional.)

Copper mineraliſed by the Muriatic Acid.

This copper-ore was found in Saxony, and had been generally miſtaken for a *micaceous*

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3. The proprietors of the mines, in purſuance of this hint, made proper pits and receptacles for the water, and have obtained, by means of ſoft iron bars put into them, ſuch quantities of copper, that theſe ſtreams are now of as much conſequence as the mines themſelves. One ton of *iron* produces near two tons of copper mud; and each ton of mud produces, when melted, 16 hundred weight of copper, which ſells for 10 *pounds ſterling* a ton more than the copper which is fluxed from the ore.

4. There is in the Iſle of *Angleſey*, on the coaſt of North-Wales, a mountain called *Paris*, which abounds in copper-ore, the bed of ore being above 40 feet in thickneſs. The leſſees of this mine annually raiſe from 6 to 7 thouſand tons of merchantable ore, and daily employ above 40 furnaces in ſmelting it. This ore contains great quantity of ſulphur, which muſt be ſeparated by roaſting, before it can be fluxed into copper. The phlogiſton, with part of the vitriolic acid, is diſperſed into the air, by the force of the fire; another part of the acid attacks and diſſolves ſuch a quantity of the copper, that the water in which the roaſted ore is waſhed (by means of old iron immerſed in it, according to the German method) produces great quantities of fine copper, ſo that the proprietors have there obtained in one year near one hundred tons of the copper precipitated from this water.

5. If this water was afterwards evaporated, it would yield *green vitriol*, or *vitriolated iron*, at nearly the rate of two *hundred tons* of *vitriol* for *each hundred* ton of *iron* at leaſt: which, at the rate of 3 *pounds* ſterling per ton, might perhaps produce very good profit to the undertakers, if any ſhould ſettle ſuch a manufacture there, *The Editor from* Bp. Watſon.

ſubſtance,

ſubſtance, which in fact it greatly reſembles.

It has not yet been found in large maſſes, but only in a ſuperficial form, like a cruſt over other ores.

It is moderately hard and friable; of a fine *green* colour, and ſometimes of a *bluiſh-green*, cryſtalliſed in a cubic form, or with a foliated texture, or in little ſcales, reſembling *green mica*, or *talc*. This ore is eaſily diſſolved by nitrous acid: the ſolution takes a green colour; and the metal may be precipitated on a poliſhed plate of iron.

If ſome drops of a *nitrous ſolution of ſilver* be mixed with it, a white powder of *luna cornea* will be precipitated, which diſcovers the preſence of the *muriatic acid* in this ore.

Dr. Werner, in his German tranſlation of the Mineralogy of our Author, deſcribes this copper-ore: he ſent a ſpecimen of it to Profeſſor Bergman, who analyſed it, as he informs us in the Sect. 191. of his Sciagraphia, as well as when he ſpeaks of the *minæ cupriferæ* in his *docimaſia humida*, p. 431.

Mongez mentions four fine ſamples of this ore, that were brought from the mines of Johnn Georgenſtad; and adds, that a ſimilar kind of copper-ore was ſold ſo late as the year 1784 at Paris, by a perſon called Dans, as a mere *green mica*. The Editor.

SECT.

SECT. 331. (part of 200.)

5. *Copper-coal ore* [a].

This copper ore coſiſts of the calces of this metal mixed with a bituminous earth. See Sect. 258 (161) pag. 501.

See Sect. 258. (161.) p. 501.

SECT. 332. (Additional.)

Obſervations on Copper.

Copper-ores are found in almoſt all parts of the world; and are eaſily diſtinguiſhed from thoſe of any other metal, by the *blue colour* they give to *volatile alkali*, on being digeſted with it, after they have been previouſly *roaſted*; otherwiſe it is poſſible that the *arſenic*, which they ſometimes contain, and even the *ſulphur*, if in ſufficient quantity, may prevent this effect, when they are in their crude natural ſtate; *viz.* before their being roaſted by the action of fire.

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[a] In the Banat of Temeſwar, below the green copper-calx, they find a compact, blackiſh-brown ſubſtance, which is there called *pitch-ore*; it contains a conſiderable quantity of copper, and, when put into the fire, does not burn with a flame. We are ſtill in want of an accurate enquiry into its conſtituent parts. *Brunnich.*

Copper mixt with black pitchy rock-oil has been found in Cornwall, according to Raſpe's account. *The Editor.*

They

They are particularly found in Spain, France, England, Norway, and Tranſylvania. The copper that comes from Japan, according to Neumann, is much ſuperior to any other that is found in Europe.

As to England in particular, no country in the world can boaſt of copper-mines more numerous, nor more productive for a longer period. It ſeems as if this Iſland was grounded on a metallic bottom, of various kinds, which will never be exhauſted by all the labours of mankind for centuries to come [*a*].

The

[*a*] Beſides the celebrated copper-mines at *Arklow*, in the County of *Wicklow*, in Ireland, there are no leſs than 17 out of the 48 counties of England, in which copper-mines are found; as mentioned by Dr. Campbell in the 2d vol. p. 44, of his *Political Survey of England*. Theſe are Cardiganſhire, Cheſhire, Cornwall, Cumberland, Derbyſhire, Devonſhire, Lancaſhire, Iſle of Man, Northumberland, Shropſhire, Somerſetſhire, Staffordſhire, Yorkſhire, Wales, Warwickſhire, Weſtmoreland, and North Britain: ſome that are worked at this time give ſuch large products of this metal, that the opening more copper-mines in this iſland would probably affect the copper trade of Europe in a very conſiderable manner. The *Ecton-mine*, in the Eſtate of the Duke of Devonſhire, on the frontiers of Derbyſhire, but properly ſituated in the county of Staffordſhire, produces at leaſt 300 tons of copper *per annum*. That of the mountain called *Paris*, in the Iſland of Angleſey, whoſe *bed of ore* is about 40 feet in thickneſs, produces about 1500 tons of copper in the year: and the copper-mines of Cornwall produce no leſs than 4000 tons in the ſame period. My late and much regreted friend, Mr. Jars, who viſited theſe mines in the year of 1770, found, upon calculation, that the annual produce of theſe mines amounted to 140,000 pounds ſterling: and M. H. Klaproth, in his *obſervations* on the foſſils of Cornwall,

The uſes of copper are very numerous, although not thoroughly known to every one. Its great ductility, lightneſs, ſtrength, and durability, render it of a very extenſive uſefulneſs. Blocks, or bars of copper, are reduced into flat ſheets of any thickneſs, by being firſt heated by the reverberation of the flame, in a low-vaulted furnace, properly conſtructed for the purpoſe; and then immediately applied between large rollers of ſteel, or rather of caſe-hardened iron, turned by a water-wheel or by the ſtrength of horſes; ſo that the hot metal is there quickly ſqueezed; and the operation is repeated, bringing the rollers every time nearer to one another, till the metallic ſheet acquires the intended thickneſs.

Theſe copper ſheets are very advantageouſly employed in ſheathing the bottoms of men of war, and other ſea-veſſels, which, by this means, are prevented from being attacked by the ſea-worms, and are kept clean from various marine concretions, ſo as to ſail with conſiderably greater ſwiftneſs. Copper ſheets are alſo employed to cover the tops of buildings, inſtead of ſlates or earthen tiles, as is uſed in Sweden; and ſome Architects have begun to introduce the uſe of copper covering into Great Britain, which is much lighter, and may be

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wall, juſt publiſhed (in 1787) aſſerts that this account is not an exagerated one. See No. 3 and 4. of the note to Sect. 330: page 696.

uſed with great advantage, although it muſt be much dearer in the prime coſt [*b*].

Sundry preparations of copper are employed in *painting*, *ſtaining*, and for colouring glaſs and enamels [*c*].

But

[*b*] The following table was publiſhed by Bp. Watſon, in his Eſſay (page 326. of his 4th vol.) by which appears the reſpective weight of each of the 5 materials here mentioned, that is required for covering a ſurface of 42 yards ſquare, *viz.*

Tile	54	hundred weight.
Coarſe ſlate	36	
Lead	27	
Fine ſlate	26	
Copper	4	

[*c*] The ſolution of copper in *aqua fortis* ſtains marble, and other ſtones, of a green colour: when precipitated with *chalk*, or *whiting*, it yields the *green* and the *blue verditer* of the painters.

According to Lewis, a ſolution of the ſame metal, in volatile ſpirits, ſtains ivory and bones: when macerated for ſome time in the liquor, they become of a fine *blue colour*, which, however, tarniſhes by expoſure to the air, and becomes green afterwards.

2. The ſame author prepared elegant *blue glaſſes*, by melting common glaſs, or powdered flint and fixed alkaline ſalt, with blue vitriol, and with an amalgam of copper: fine green ones were made with green verditer, and with blue verditer, as well as with the precipitate of copper, made by fixed alkalies, and with a precipitate by zinc; and a *reddiſh glaſs* was produced by the calx and ſcoria of copper made by fire alone. Even in this vitreous ſtate, it ſeems as if a continuance of fire had the ſame effect in regard to colour, as air has upon copper in other forms: as ſome of the moſt beautiful *blue glaſſes*, by continued fuſion, have changed to a *green colour*. Editor.

3. Verdegris, called *ærugo*, *æs viride*, and *viride æris*, in Latin, is a preparation of copper diſſolved by the vegetable acids;

But the moſt common uſe of copper is, to make all ſorts of *large ſtills*, *boilers*, *pots*, *funnels*, and other *various veſſels*, employed by *diſtillers*, *dyers*, *chemiſts*, and various other ma-

acids; which act on this metal, diſſolving it very ſlowly, but in conſiderable quantities. It produces a fine green pigment for painting, both in oil and in water colours, inclining more or leſs to the *blueiſh*, according to circumſtances. This preparation is made in large quantities in France, particularly about Montpelier, by ſtratifying clean copper-plates with the huſks of the grapes, that remain after the juice has been preſſed out, to be turned into wine by a proper fermentation. The huſks ſoon become acid, and corrode the copper-plates: their whole ſurface is covered, after a certain time, with a very beautiful green cruſt, which is the *verdegris*. This is nothing elſe but the copper corroded by the acid of tartar, analogous to the acid of vinegar, which abounds in the wines of Languedoc, and eſpecially in the huſks, and ſtones of grapes, which have a very auſtere taſte. *Verdegris* is a very violent poiſon.

4. This ruſt of copper, *viz.* the *verdegris*, is not quite ſaturated, nor converted into a neutral ſalt, for it is ſoluble in water: nor does it cryſtallize till it is purified by a new ſolution in diſtilled vinegar; which is then called, though improperly, *diſtilled verdegris*, or *flowers of copper*. The cakes of verdegris for this operation muſt be choſen, neither moiſt nor unctuous, but dry, compact, and of an uniform texture, of a lively green colour throughout, and as free as poſſible, from white or black ſpecks, and ſeeds, or ſtalks, of the grape. The Dutch, who prepare theſe cryſtals in a large quantity, after duly evaporating the ſolution, ſet it to ſhoot, not, as is cuſtomary in a cold, but in a warm place, as practiſed for making *ſugar candy*. If theſe cryſtals be diſtilled, the moſt ſtrong acetous acid is produced, called *Radical vinegar*. But if rectified ſpirits of wine, or ſome volatile alkalies, be added to that acetous ſolution of *verdegris*, ſmall blue cryſtals will be immediately formed, called *antipileptic cryſtals of copper*, as Newmann aſſerts. *The Editor chiefly from* Newman and Lewis.

nufacturers,

nufacturers, who make uſe of large quantities of hot liquors in their various operations.

Unhappily, the good qualities of copper, and chiefly its ductility and great durability, induced our anceſtors to employ it likewiſe, without due conſideration, in all kinds of kitchen veſſels, as *boilers*, *porridge-pots*, *kettles*, *ſauce-pans*, &c. as they were not aware of the poiſonous qualities of this metal, whenever its ſolution [*d*], even

[*d*] Copper diſſolves not only in *every acid*, but in *alkalies* alſo, both *fixed* and *volatile*, in *neutral* ſaline-liquors, and in *oils*: when diſſolved, it exhibits fine *blue*, *green*, or *bluiſh* colours, by which this metal is readily diſtinguiſhed, however mixed or diſguiſed with other ſubſtances. Even pure water, ſuffered to ſtand long in copper veſſels, extracts ſo much as to gain a coppery unwholeſome taſte: and it is remarkable, that fluid liquors become more impregnated with this taſte on ſtanding in the cold, than if boiled in the veſſel for an equal time. The confectioners prepare acid ſyrups, even thoſe of orange and lemon-juice, by boiling them in clean copper veſſels, without the preparation's receiving the ill taſte of the metal; whereas either the juices by themſelves, or the ſyrups made from them, and, what is ſtill worſe, the fricaſſees and other culinary ragouts, if kept cold in clean copper veſſels, ſoon become impregnated with a metallic taſte, and acquire the poiſonous qualities of the copper.

2. Many have deceived the public, by affirming, that copper veſſels, if well tinned in the inſide, cannot communicate any poiſonous quality to the aliments cooked therein. But, as Gellert obſerves (pag. 262. of his *Metallurgic (hymiſtry)*, it is by no means ſufficient; becauſe there will either ſome ſmall imperceptible parts remain uncovered with the tinning pewter; or ſuch minute parts will be rubbed off in time by the uſe and cleaning of the veſſel, which being then expoſed to the effect of the acting liquors, will produce the ſame danger, by generating the poiſonous verdegris, and diſſolving the ſurface of the copper.

3. Even,

even in the ſlighteſt quantity, is once taken internally with any ſort of food, or otherwiſe.

Examples are too frequent of the fatal conſequences, from eatables that had received a taint from *copper* veſſels, and even from *ſilver* ones that were largely alloyed with *copper*; whether on account of the acid nature of the food itſelf, which diſſolves and corrodes the ſurface of the metal it touches; or from the veſſel having contracted the copperiſh-green ruſt, called *verdigris*, by laying expoſed to the air; a poiſon, which is ſo readily formed as to baffle the common attention of the ſcullions and cooks. I ſaw at Paris the melancholy ſpectacle of a middle aged man, of a ſtout bodily complexion, but who laboured

3. Even if the danger from the copper could ſafely be prevented, it is well known, that inſtead of employing pure tin, which is not reckoned an unwholeſome metal, the mixture generally uſed for tinning copper, or braſs veſſels, conſiſts of 3 parts of lead and 5 of pewter, or at beſt of 10 of lead with 16 of tin: and it has been already mentioned (Sect. 304. Note [*b*]. N° 4. and N° 14 of the Note [*a*] to p. 670), that a ſolution of lead taken internally with our food, or in any other way, is likewiſe highly pernicious to the life of animals.

4. Inſtead of that mixture of tin with lead, zinc alone may be advantageouſly employed to cover the inſide of copper or braſs-veſſels, as hath been propoſed and executed at *Rouen* in France; and perhaps in other manufactures of this kind (as Watſon relates, p. 177 of the 4th vol. of his Eſſays.) In this caſe the laſt objection, from the unwholeſomeneſs of the lead, would be obviated; but at any rate there remains ſtill the danger ariſing from the wearing off the zinc in ſome parts of the internal ſurface of the veſſels: and conſequently no copper, nor braſs-veſſels of any ſort, ſhould ever be employed for culinary purpoſes. *The Editor.*

under

under a paralytical diſorder, and was deprived of the uſe both of his limbs and of his intellectual powers, during the laſt four, or more years of his lingering life: his diſorder was produced by eating a fricaſſée, that remained the preceding night in the ſtewing copper-pan in which it had been dreſſed. Application had been made to the beſt phyſicians, but they were unable to give him the leaſt relief from ſo melancholy a ſituation [*e*].

Although

[*e*] 1. Hardly a year paſſes without hearing of whole families, and numerous gueſts, that have been deſtroyed by this kind of poiſon of copper, or its green-ruſt, which happened to be diſſolved in the ſoups and ſtews of their meals; and, if death do not enſue, as in the caſe mentioned in the text, it is certain at leaſt, that great part of the chronical diſeaſes, palſies, gripings in the bowels, and other habitual complaints, which are ſuppoſed to proceed from other cauſes, do originate from the pernicious old and vulgar cuſtom of employing this poiſonous metal in our kitchens, on account of the œconomy ſuppoſed to ariſe from its durability and neat appearance. To my own knowledge, the late Marquis de Courtanvaux, and a few others were taught at laſt from their own danger not to allow the leaſt veſſel of copper or braſs, in their kitchens, inſtead of which they ſubſtituted thoſe of *plated*, *forged*, and *caſt-iron*, properly tinned in the inſide.

2. In conſequence of ſome repreſentations from the *College of health*, the uſe of *copper* veſſels, in the fleets and armies of *Sweden*, was aboliſhed in the year 1754; and *tinned iron* (though it would be ſtill better, if *tinned with zinc*) was ordered to be ſubſtituted in their ſtead, as appears by the Memoires of the Pruſſian Academy, quoted by Dr. Watſon, page 150 of the 4th vol. of his Eſſays. It is indeed a general opinion, of the beſt phyſicians of the age, that many of the violent and obſtinate diſeaſes of the European armies, and of the crews of men of war, and other large ſhips, intirely proceed from the uſe of greaſy and dirty *copper*, or *braſs veſſels*, employed in the cooking of their meſſes.

Although copper, when pure [*f*], is extremely valuable on account of its ductility, lightneſs,

3. Neumann knew a perſon, who having accidentally ſwallowed a braſs-ſleeve button, was ſeized with the moſt violent ſymptoms, and died in miſery; no medicines giving any effectual relief; and he alſo knew various inſtances of vehement vomitings and convulſions, which proceeded from the *unguentum ægyſptiacum*, whoſe baſis is *verdigris*, applied to ulcers in the mouth. *See the firſt vol. of his works* in 8vo. pag. 98. The Editor.

[*f*] 1. It is well known that the impurity of copper proceeds from the mixture of heterogeneous ſubſtances that are alloyed with it, on account of being naturally contained in the copper-ores. Iron and arſenic are the chief of theſe natural mixtures. The copper ores of *variegated* colours, the *white*-copper ores, and generally thoſe mineralized by ſulphur, contain a greater proportion of iron: whilſt the *blue* and *green* copper ores commonly produce a purer metal, being free, for the moſt part, of any conſiderable ferrugineous mixture.

2. The great aim, therefore, of the metallurgiſt muſt be directed to ſeparate theſe mixtures from the copper, beginning by the proper examination of the ore, and by aſcertaining the proportion of ſulphur that may be required to ſcorify the quantity of iron there contained. The ore ſhould always be roaſted by a ſlow fire, in a cloſe furnace, which contributes the beſt towards ſcorifying the ferrugineous and heterogeneous mixtures; and the ſame operation muſt be repeated after the ſecond and third fuſion of the metal, till its grain becomes of an homogeneous fine texture. The mixture of ſulphureous pyrites in the fuſion of the metal contributes towards obtaining this object; if their quality be choſen, according to the quantity of ſulphur wanting.

3. But in the ſecond, third, and following operations, only pure ſulphur ſhould be added, to ſcorify the remainder of the iron, that is ſtill intermixed with the copper. This ſhould be done when the metal is already well fuſed; covering it immediately with a proper quantity of charcoal, and ſeparating the ſcoria or droſs formed on the ſurface of the fuſed metal.

The

lightneſs, and ſtrength; it is, however, leſs uſeful, on many occaſions, from the difficulty of forming large maſſes of work; as it is not an eaſy matter to caſt copper ſolid, ſo as to retain all its properties entire. For if the heat be not ſufficiently great, the metal proves deficient in toughneſs when cold; and if the heat be raiſed too high, or continued for a length of time, the copper bliſters on the ſurface, when caſt in the moulds: ſo that the limits of its fuſion are very contracted. And from theſe circumſtances, pure copper is rendered leſs applicable to ſeveral purpoſes.

We find, however, that the addition of a certain proportion of zinc removes almoſt all theſe inconveniencies, and furniſhes a mixed metal more fuſible than copper, very ductile and tenacious when cold, which does not ſo readily ſcorify in a moderate heat, and which is leſs apt to ruſt from the action of air and moiſture.

Copper is the baſis of ſundry compound metals for a great number of mechanical and œconomical uſes of life, ſuch as *braſs* [g], *princes-*

4. The copper extracted from thoſe mines near Newſol, in Upper Hungary, is ſaid to be uſually melted 14 times, before it is fit for uſe. Theſe are the greateſt copper-mines in all Hungary. There are, however, other mines, whoſe copper requires far leſs fuſions to be well purified.

5. The above was the proceſs of Mr. Delius, director of the mines of Bannat near Temeſware, in Hungary, propoſed by him to the Imperial Board of the Auſtrian Mines. *See Journal de Phyſique for* July 1780.

[g] 1. *Braſs* is frequently made by cementing plates of copper with *calamine*, where the copper imbibes one-fourth

princes-metal, *tombac*, *bell-metal*, *white-copper*, &c.

If the mixture is made of four to ſix parts of copper, with *one* part of zinc, it is called *Prince's-metal*. If more of the copper is taken, the mixture will be of a deeper *yellow*, and then goes by the name of *Tombac*, or *Tompac*, as Gellert calls it (p. 359. of his *Metallurgic Chemiſtry*, edit. of 1776.); ſo that even copper by itſelf has got that name, ſays he, when its ſurface is only ſtained, by the fumes of zinc, with a gold-yellow colour, which is done, by mixing flowers of zinc with charcoal-duſt, throwing this mixture into a heated muffel, and immediately holding a piece of red-hot copper in the fumes riſing from the zinc.

Bell-metal is compoſed of copper and tin. When this laſt amounts to one-third of the maſs, it becomes of a very beautiful yellowiſh-white.

It

or one fifth its weight of the zinc which riſes from the calamine. The proceſs conſiſts in mixing three parts of calamine and two of copper with charcoal duſt in a crucible, which is expoſed to a red heat for ſome hours, and then brought to fuſion. The vapours of the calamine penetrate the heated plates of copper, and add thereby to its fuſibility. It is of great conſequence, for the ſucceſs of this proceſs, to have the copper cut into ſmall pieces, and intimately blended with the calamine.

2. In moſt foreign founderies the copper is broken ſmall by mechanical means, with a great deal of labour; but at Briſtol the workmen employ an eaſier method. A pit is dug in the ground of the manufacture, about 4 *feet* deep, the ſides of which are lined with wood. The bottom is made of cop-

per

It is remarkable that zinc, which is ſcarcely maleable, on being united with copper, produces malleable braſs; whilſt bell-metal is compoſed of malleable tin, and is ſo brittle, that it may be reduced to powder.

The ſpecific gravity of bell-metal is likewiſe ſingular; for if the tin is about one-third of the maſs, it is heavier than the braſs itſelf; whilſt, in other doſes, it is only as heavy as the copper. Bell-metal is extremely hard and ſonorous, and is leſs ſubject to alterations by expoſure to the air, than any other cheap metal. On this account it is advantageouſly employed in the fabrication of various utenſils and articles, as *canons*, *bells*, *ſtatues*, &c. in the compoſition of which, however, other metals are mixed in various proportions, according to the fancy and experience of the artiſt.

White-

per or braſs: and is moveable by means of a chain. The top is made alſo of braſs with a ſpace near the centre, perforated with ſmall holes, which are luted with clay: through them the melted copper is poured, which runs in a number of ſtreams into the water, and this is perpetually renewed by a freſh ſtream, that paſſes through the pit. As the copper falls down it forms itſelf into grains, which collect at the bottom. But great precaution is required to hinder the dangerous exploſions, which melted copper produces, when thrown into cold water, which end is obtained by pouring ſmall quantities of the metal at once. The granulated copper is compleatly mixed with the powdered calamine, and fuſed afterwards. The proceſs laſts 8 or 10 hours, and even ſome days, according to the quality of the calamine.

3. It is a wonderful thing, ſays Cramer, that zinc itſelf, being ſimply melted with copper, robs it of all its mal-

White-copper is prepared with arſenic. Neumann preſcribes, to mix equal parts of arſenic and nitre, pulverized and mixed together, which being injected into a red-hot crucible, are to be kept in a moderate fire, till they ſubſide and flow like fuſed wax. One part of this mixture is to be injected into four parts of melted copper; and the metal, as ſoon as it appears thoroughly united together, is to be immediately poured out. The copper is thus whitened; and if melted with a conſiderable part of ſilver, is ſo much improved, that vaſes, candleſticks, and various other pieces being made with it, hardly can be diſtinguiſhed from true ſilver. The *white-copper* that is imported from China and Japan, ſeems to be nothing elſe than a mixture of *copper* and *arſenic*, ſince Geoffroy aſſerts that, by repeated fuſions, arſenical fumes were exhaled from it; and at laſt the red copper was all that remained, having loſt with its

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leability; but if it be applied in form of vapour from the calamine, the ſublimates, or the flowers, it does not cauſe the metal to become brittle.

4. The method mentioned by Cramer to make braſs from copper, by the volatile emanations of zinc, ſeems to be preferable to to any other proceſs, as the metal is then preſerved from the heterogenous parts contained in the zinc itſelf, or in its ore. It conſiſts in mixing the calamine and charcoal with moiſtened clay, and raming the mixture to the bottom of the melting pot, on which the copper, mixed alſo with charcoal, is to be placed above the rammed matter. When the proper degree of heat is applied, the metallic vapour of the zinc, contained in the calamine, will tranſpire through the clay, and attach itſelf

its whiteneſs one-ſeventh part of its former weight, as Lewis relates.

But the attention of the philoſopher is more particularly directed to that kind of *white-copper* with which ſpeculums of reflecting teleſcopes are made [*b*]. *The Editor.*

SECT.

ſelf to the copper, leaving the iron and the lead, which were in the calamine, retained in the clay, without mixing with the upper metal. Dr. Watſon ſays, that a very good metallurgiſt, of Briſtol, named John Champion, has lately obtained a patent for making braſs, by combining zinc in the vapourous form, with heated copper plates; and that the braſs from this manufacture is reported to be of the fineſt kind; but he knows not whether the method there employed is the ſame here mentioned from Cramer.

5. Braſs is ſometimes made in another way, by mixing the two metals directly: but the heat requiſite to melt the copper, makes the zinc burn and flame out, by which the copper is defrauded of the due proportion of zinc. If the copper be melted ſeparately, and the melted zinc poured into it, a conſiderable and dangerous exploſion enſues; but if the zinc is only heated and plunged into the copper, it is quickly imbibed, and retained. The union, however, of theſe two metals ſucceeds better, if the flux, compoſed of inflammable ſubſtances, be firſt fuſed in the crucible, and the copper and zinc be poured into it: as ſoon as they appear thoroughly melted, they are to be well ſtirred, and expeditiouſly poured out; or elſe the zinc will be inflamed, and leave the red copper behind.

6. Neumann ſays, that 64 pounds of copper imbibe 26 pounds from the calamine, and yield 90 pounds of braſs. In general, all the yellow compounds are nothing elſe but the ſame two ſubſtances in different doſes. When the zinc enters in a greater quantity into the braſs, the colour of the compounds becomes more and more pale. The quantity of zinc in good braſs may be about one third of the weight. *The Editor chiefly from* Cramer.

[*b*] 1. The beſt proportions to make this kind of *white-copper*, are 32 *parts* of fine *red copper*, *one part* of braſs; *one*

part, alſo of *ſilver*; 15 parts of *tin* (of the beſt ſort called *Grain-tin*); and about 3 *parts* of *white-arſenic*. The proceſs given by the late J. Edwards, who was rewarded by the *Board of Longitude*, for diſcloſing it to the public, was publiſhed in the Nautical Almanack for 1787, and is as follows: Melt the copper in a large crucible, employing ſome *black flux*, compoſed of 2 *parts* of *tartar*, and *one* of *nitre*; when melted, add to it the *braſs* and the *ſilver*. Let the *pure tin* be melted in another crucible, alſo with ſome *black flux*. Take them both from the fire, and pour the melted *tin* into the fuſed maſs in the large crucible. Stir the whole well with a dry ſpatula of *birch*, and pour off the fuſed metal immediately into a large quantity of cold water. The ſudden chill of the water will cauſe the fluid metal to divide into an infinite number of ſmall particles, which will cool inſtantly.

2. If the copper be compleately ſaturated, the fracture of one piece of this mixed metal will appear *bright*, and of a *glaſſy look*, reſembling the face of *pure quickſilver*. But if it is of a *brown-reddiſh colour*, it wants a little more *tin*. To aſcertain the required proportion, melt a ſmall quantity, known by weight, of the mixed metal, with a known very ſmall part of tin; and, if neceſſary, repeat the trial with different doſes, till the fracture of the new mixture looks as already deſcribed. Now having aſcertained the neceſſary addition of *tin* that is required, proceed to the laſt melting of the whole metal, together with the additional proportional doſe of tin; fuſe the whole, obſerving the ſame cautions as before; and you will find that the mixture will melt with a much leſs heat than that for the firſt fuſion. Have ready as many ounces of white arſenic in coarſe powder as there are pounds in the weight of the metal; wrap up the *arſenic* in a ſmall paper, and put it, with a pair of tongs, into the crucible; give it a good ſtir with the ſpatula, retaining the breath to avoid the arſenical fumes or vapours (which however are not found to be hurtful to the lungs) till they diſappear; take the crucible off the fire, clear away the droſs from the top of the metal, pour in about one ounce of powdered *roſin* with as much *nitre*, in order to give the metal a clean ſurface, and pour out the metal into the moulded flaſks.

3. The *ſpeculum* ſhould be moulded with the concave ſurface downwards, and many ſmall holes ſhould be made through

SECT. 333. (201.)

Iron. *Ferrum*, *Mars*, Lat. *Jern*, Swed. *Eiſen*, Germ. *Fer*. French.

General Properties of Iron. [*a*].

This metal is

a. Of a blackiſh blue ſhining colour.

It

through the ſand upwards, to diſcharge the air. The moulding ſand from *Highgate* near London, uſed by the founders, is as good as any, for caſting theſe metallic mirrors.

N. B. The caſt metal ſhould be taken out from the ſand of the flaſks, whilſt it is hot; or elſe it may happen to crack, if let to cool within. *The Editor.*

[*a*] 1. Iron is the moſt diffuſed and the more abundant of all metallic ſubſtances; ſince it is not only found either intermixed with, or united to, all the *foſſil bodies* of the earth; but alſo, in combination with the productions of the two other kingdoms of nature, the *vegetable* and the *animal bodies*, whoſe juices and blood are coloured by it; and there is even a probability that theſe organic ſubſtances have the power of producing this metal by themſelves; for it is known that it may be extracted even from the aſhes of thoſe plants that had been raiſed in pure water. Iron is contained in almoſt all the coloured ſtones, even in the hardeſt and moſt brilliant gems, in the bitumens, moulds, and waters, and in the greateſt number of metallic ores.

2. This metal in its reguline ſtate is of a more or leſs *dark-blue* colour in various ſpecimens. It may receive ſuch a poliſh as to appear *white*; and, after being hardened, it may be poliſhed ſo highly as to ſhine with an amazing brilliancy. However, it ſoon tarniſhes, if expoſed to the action of the atmoſphere, and to moiſt air, in particular; taking a

duſky

b. It becomes ductile by repeated heating between coals, and hammering.

c. It is attracted by the loadſtone, which is an iron ore; and the metal itſelf may alſo be rendered magnetical.

d. Its ſpecific gravity to water is as 7,645, or 8000 : 1002.

It

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duſky blackiſh hue, and contracting a yellowiſh and reddiſh ruſt on its ſurface. Nevertheleſs, it has been obſerved that hard iron, or ſteel, well poliſhed, has ſometimes eſcaped being attacked by ruſt, under running water.

3. Iron has a particular and very ſenſible ſmell, when ſtrongly rubbed, or heated. It produces a ſtyptic taſte, which it communicates to the water in which it is extinguiſhed after ignition.

4. Its tenacity, ductility, and malleability, are very great. It exceeds every other metal in elaſticity and hardneſs, when properly tempered. An iron wire of *one-tenth* of an inch thick, is able to ſupport 450 pounds weight, without breaking, as Wallerius aſſerts.

5. Iron extends difficultly under the hammer, but it may be extended to a great degree, and drawn into wire as ſlender as the fineſt hairs. It is more eaſily malleable when ignited than when cold; whereas other metals, though ductile when cold, become quite brittle by heat.

6. It grows red-hot ſooner than other metals: nevertheleſs, it melts the more difficultly of all, platina and manganeſe excepted. Expoſed to a white heat, leſs than ſufficient for its fuſion, it contracts a ſemivitreous coat, which burſts at times, and flies off in ſparkles. It does not tinge the flame of burning matters into bluiſh or greeniſh colours, like other imperfect metals, but brightens and whitens it; hence the filings of iron are uſed in compoſitions of fire-works, to produce what is called *white-fire*.

7. When ſtrongly heated, it appears covered on its ſurface, with a ſoft vitreous matter like varniſh; in this ſtate pieces of iron may be made to cohere to one another, by being hammered together; this is called the *welding* of iron; the joint unites ſo well as not to be diſcovered afterwards, if properly made.

e. It calcines eaſily to a black ſcaly calx, which, when pounded, is of a deep red colour.

f. When this calx is melted in great quantity with glaſs compoſitions, it gives a blackiſh brown colour to the glaſs; but in a ſmall quantity a greeniſh colour, which at laſt vaniſhes,

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made. This property of *welding* is not found in the other metals.

8. *Iron*, or rather *ſteel*, expands the leaſt of all hard metals by the action of heat; but *braſs* expands the moſt; and on this account theſe two metals are employed in the conſtruction of *compound pendulums* for the beſt ſort of regulating clocks, for aſtronomical purpoſes. Each of theſe pendulums conſiſt of 5 rods of ſteel, and 4 of braſs; and, on account of their appearance, are called *grid-iron pendulums*. Theſe 9 rods are placed in an alternate order, the middle rod being of ſteel, and ſuſpending the lenticular ball. They are ſo connected with each other at their ends, that while the expanſion of the ſteel rods has a tendency to depreſs the center of oſcillation, the expanſion of braſs-rods acting upwards, tends to raiſe it; and, being duly proportioned, their expanſions balance and correct each other, preſerving the pendulum of the ſame length in any different temperature of the atmoſphere.

The late ingenious John Harriſon was the inventor of this uſeful contrivance about the year 1725 or 26; and it is rather ſingular, that the laborious Muſſchenbroek attributes this invention to G. Graham, in the article 674 of his *Introduction to Natural Philoſophy*, only becauſe the firſt pendulum he heard of this kind, had been made by this laſt excellent artiſt.—Monſ. De la Lande, however, has done juſtice to the real inventor, in the article 2462 of his *Aſtronomy*, where he deſcribes this conſtruction; and its great advantages for the regularity of the going of aſtronomical regulators.

9. It appears, however, from the experiments of Mr. Smeaton in the *Philoſ. Tranſact.* for 1750, that zinc ſuffers ſtill a greater expanſion from the ſame quantity of heat, than

vaniſhes, if urged by a ſtrong degree of heat.

g. It is diſſolved by all ſalts, by water, and likewiſe by their vapours. The calx of iron is diſſolved by the ſpirit of ſea-ſalt, and by aqua regia.

The

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any other metal. Conſequently fewer rods of ſteel and zinc may produce the ſame effect when properly combined. Only 3 rods of ſteel, and *two* of zinc, mixed with ſome *ſilver*, produce, in our beſt Engliſh regulators, the very ſame effect which formerly required almoſt double the number of theſe metallic rods. The following table of the expanſions of different metals, obſerved by Mr. Smeaton, with his new Pyrometer, is extracted from the XLVIIIth vol. of the Phil. Tranſact. p. 612.

13. *Table ſhewing what is the expanſion of a* foot of *the following* metallic ſubſtances, *by the* temperature of 180 *degr.* of Fahrenheit's thermometer, *viz. from the* freezing point *to that of* boiling water, *expreſſed* in 10,000 *parts of the Engliſh inch.*

White glaſs barometer tube	100	Spelter ſolder, viz. braſs 2. zinc 1.	247
Martial Regulus of antimony	130	Fine pewter	274
Briſtered ſteel	138	Grain tin	298
Hard ſteel	147	Soft ſolder, viz. lead 2. tin 1.	301
Iron	151	Zinc 8. tin 1. a little hammered.	323
Biſmuth	167	Lead	344
Hammered copper	204	Zinc or ſpelter	353
3 parts of copper with 1 of tin	218	Zinc hammered an inch. per foot.	373
Caſt braſs	225		
16 parts of braſs with 1 of tin	229		
Braſs-wire	232		
Speculum metal	232		

11. Iron, in the act of fuſion, inſtead of continuing to expand, like the other metals, ſhrinks, as Dr. Lewis obſerves; and thus becomes ſo much more denſe, as to throw up ſuch part, as is unmelted, to the ſurface; whilſt pieces of *gold*, *ſilver*, *copper*, *lead*, and *tin*, put in the reſpective metals in fuſion, ſink quickly to the bottom. But in its re-

turn

h. The calx of the diſſolved metal proves yellow, or yellowiſh brown; and in a certain degree of heat, it turns red.

i. The ſame calx, when precipitated from acids, by means of the fixed alcali, is of a greeniſh colour; but it becomes blue, when precipitated

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turn to a conſiſtent ſtate, inſtead of ſhrinking, like the other metals, it expands; ſenſibly riſing in the veſſel, and aſſuming a convex ſurface, whilſt the others ſubſide, and appear concave. This property of iron was firſt taken notice of by Reaumur, and excellently fits it for receiving impreſſions from the moulds into which it is caſt; being forced into their minuteſt cavities. Even when poured thick into the mould; it takes, nevertheleſs, a perfect impreſſion; and it is obſerved, that caſt iron is ſomewhat larger than the dimenſions of the mould; whilſt caſt figures of other metals are generally ſmaller.

12. The *vitriolic acid* diſſolves iron readily, and forms the *green vitriol* of Sect. 207. This ſalt, in actual ſolution, is deprived of phlogiſton by the contact of air, and the attraction between the acid and the metallic particles is diminiſhed; a quantity of ochreous matter, or ferrugineous calx, therefore, falls to the bottom in this caſe, and the liquor, as well as the cryſtals, obtained by evaporation, are paler.

13. This acid, the vitriolic, requires to be diluted with 304 times its quantity of water, to enable it effectually to diſſolve iron; and, during the diſſolution, a ſtrong aërial fluid ariſes, called *inflammable air*, which, on being mixed with atmoſpheric air, takes fire at the approach of the flame of a candle. A glaſs phial, of about two ounces meaſure, with one-third of *inflammable air*, and the reſt of *common-air*, produces a very loud report, if opened in the ſame circumſtance; and if it be filled with two-thirds of *inflammable air*, mixed with one of *dephlogiſticated air*, the report will be as loud as the exploſion of a piſtol with gun powder. It is highly probable, and even demonſtrated, that inflammable air is the true *phlogiſton*, whoſe real exiſtence ſome modern philoſophers endeavour to overthrow. *See note* a *to page* 441: *and* Prieſtley's 2d vol. on *different kinds of air*, pag. 98 and 99.

Dilute

tated by means of an alcali united with phlogiſton, in which laſt circumſtance the phlogiſton unites with the iron. Theſe two precipitates loſe their colour in the fire, and turn brown.

The

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15. Dilute *nitrous acid* diſſolves iron, but this ſaline combination is incapable of cryſtallizing. Strong *nitrous acid* corrodes and dephlogiſticates a conſiderable quantity of iron, which falls to the bottom.

Marine acid likewiſe diſſolves iron, and this ſolution is alſo incryſtallizable.

16. The *Pruſſian acid* precipitates iron from its ſolutions, in the form of *Pruſſian blue*.

N. B. An account of this acid will be given in the *Article of Aſſaying by the Humid way*.

17. This metal is likewiſe ſenſibly acted upon by alkaline and neutral liquors, and corroded even by thoſe which have no perceptible ſaline impregnation; the oils themſelves, with which iron utenſils are uſually rubbed to prevent their ruſting, often promote this effect in ſome meaſure, unleſs the oils had been previouſly boiled with litharge, or calces of lead.

18. Galls, and other aſtringent vegetables, precipitate iron from its ſolutions, of a deep *blue* or *purple colour*, of ſo intenſe a ſhade as to appear *black*.

It is owing to this property of iron, that the common writing ink is made by the proceſs deſcribed in the Note N° 9 to p. 405; although the doſes and circumſtances may be changed in different ways without affecting the ſucceſs.

The infuſion of galls, and alſo the Pruſſian alkali, are teſts of the preſence of iron, by the colours they produce on any fluid. Acids, however, diſſolve the coloured precipitates by the former; and from hence ariſes that the marine acid is ſucceſsfully applied to take off ink-ſpots, and iron ſtains from white linens. Alkalis, however, convert theſe iron-precipitates into a brown ochre.

20. Iron has a ſtrong affinity with ſulphur. If a bar of iron be ſtrongly ignited, and a roll of brimſtone be applied

to

k. The vitriol of iron is green.

l. It is the moſt common metal in nature, and at the ſame time the moſt uſeful in common life; notwithſtanding which, its qualities are perhaps very little known.

SECT.

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to the heated end, it will combine with the iron, and form a fuſible maſs, which will drop down. A veſſel of water ought to be placed beneath, for the purpoſe of receiving and extinguiſhing it, as the fumes would otherwiſe be very inconvenient to the operator.

21. A mixture of iron-filings and ſulphur in powder, moiſtened with water, and preſſed ſo as to form a paſte, will in a few hours ſwell, become hot, fume, and even burſt into a flame, if the quantity is large. The reſiduum furniſhes martial vitriol. This proceſs is ſimilar to the decompoſition of martial pyrites, from which ſome philoſophers account for hot ſpring waters, and ſubterraneous fires. The mixture of water in this paſte ſeems to be neceſſary to enable the vitriolic acid of the ſulphur to act on the iron.

22. Iron is diſſolved by all metals, made fluid by a ſufficient heat, except *lead*, on which it floats diſtinct as oil upon water. Gold, of all metals, acts on it the moſt powerfully; though, as Cramer obſerves, if the iron contains any ſulphur, it can ſcarcely be made to unite at all with gold.

24. It refuſes likewiſe to unite to mercury; and no method has hitherto been diſcovered to amalgamate theſe two ſubſtances together, though in ſome circumſtances a mutual coheſion has been obſerved to take place, as was noted at p. 580. N° 3.

24. Among the ſemi-metals, *zinc* is the moſt difficultly combined with iron; not from a natural indiſpoſition to unite, but from the zinc being difficultly able to ſuſtain the due degree of heat. This mixture is hard, ſomewhat malleable, and of a white colour, approaching to that of ſilver.

25. *Regulus of Antimony*, as ſoon as it melts, begins to act on iron, and diſſolves a great quantity of it. If this regulus, when fuſed, be ſtirred with an iron rod, the end of it will be

ſoon

SECT. 334. (Additional.)

Native Iron.

It is now known that *native iron* exiſts in many places. The moſt remarkable maſs of this ſort is that diſcovered in Siberia, which weighed 1600 pounds. It is of that ſpecies called *Red-ſhort*, being *malleable* while cold, but *brittle* when red-hot. *Kirwan.*

It can hardly be doubted, but that this great maſs of iron, brought by Pallas from Siberia into Europe, is the produce of nature. Its compoſition reſembles that of forged iron; for a centenary (= 63 *grains*) yields, by means of the muriatic acid, 49 cubic inches of inflammable air; and from many experiments it is found that ductile iron yields from 48 to 51 of the ſame inches. *Bergm.* Sciagraph.

Margraaf found ſome of this kind of iron, in the form of ridges, at Ebenſtock (or Eybenſtock) in Saxony. *Fourcroy.*

Native iron has been found in a *cubical form*, at Senegal in Africa, out of which the black inhabitants make various veſſels for

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ſoon melted. According to Cramer, iron mixed with Antimony, is not attracted by the Magnet.

Arſenic likewiſe unites eaſily with iron, and diſcovers a great attraction to it, forſaking all the other metals to combine with this. It renders the iron white, very hard, and brittle. *The Editor chiefly from* Newman, Lewis, Fourcroy, Nicholſon, &c.

their

their own uſe; alſo at Eibenſtock, on the Margravate of Miſnia, in the Upper Saxony, and at Stiria on the Circle of Auſtria. Some native irons have been found in a polyédrical granulated form, and of a bright yellow colour, which on being poliſhed ſhew their proper metallic colour; theſe two ſpecies of native iron are mentioned by Wallerius, in his Spec. 321 [*a*].

Monet, quoted by Mongez, mentions a piece of many pounds weight, that has all the qualities of a good iron, and is kept in the Collection of the College of the Mines at Freyberg. Other ſpecimens have been found alſo of the kind near Bareith, which were malleable: and laſtly, the ſame Mongez mentions three ſpecimens of *native iron*, kept in the King's cabinet in the *Royal Garden* at Paris; one of which was found at Kaumſdorf in Thuringia; this is ſurrounded by an ore of the hepatic iron, and has a cavity with ſome protuberances of a brown hæmatites. The other

[*a*] Wallerius makes no difficulty in admitting that *native iron* has been found, without any preceding operation of art; and even anſwers to the objection ſtated by Lehman, who ſays, that perhaps the ſpecimens of *native iron* might be produced by volcanic fires; by obſerving that the preſence of proper fluxes cannot be ſuppoſed to exiſt in the volcanic craters. But I muſt acknowledge, that after having examined and conſidered with proper attention the ſpecimen of *native iron* from Siberia, mentioned in the next *Note*, I cannot account for its formation in any other way than by its being a real volcanic production. *The Editor.*

two are from the *native iron*, found by Pallas on the Emir Mountains of Siberia [*b*].

SECT. 335. (202.)

Calciform Iron.

Iron is found in a calciform ſtate [*a*].

In

[*b*] I was favoured with a ſpecimen of this native iron from Siberia, by the generous friendſhip of Dr. Matthew Guthrie, reſident at St. Peterſburg, who deſcribed it to me by the following words, in his letter of the 9th of Sept. 1777. "N° 3d is a piece of the curious maſs of native iron, "diſcovered by my friend Pallas, on a mountain in Siberia, "and is the firſt inſtance of this metal being found in this "very pure malleable ſtate. The pores of it were filled "with a yellow vitreous matter, ſo hard as to cut glaſs, of "which I alſo ſend a little in a paper apart, as it fell out "on cutting ſpecimens from the large maſs. I am very "ſorry that the ſpecimen of iron is ſo ſmall, but it is a "very good one, as it ſhows not only the cellular texture of "the maſs, but the varniſh which Pallas ſpeaks of, as lining "its hollows; and is exactly in ſmall, what the maſs is in "large." On my receiving this curious and wonderful ſpecimen, I found that every circumſtance correſponded exactly to the deſcription given by the Doctor. The little cells were like ſpherical cavities; the varniſh ſtill adhering to ſome parts, appeared to be the contiguous cruſt of the glaſſy ſubſtance that was within; and the metallic maſs was perfectly malleable, and rather ſofter than common iron. I made a preſent of this curious ſample to my late worthy friend, the celebrated Dr. Fothergill, from whoſe hands it probably has paſſed to ſome other cabinet; ſince I was told, it was not found in his own, after his deceaſe. *See Journal de Phyſique, ſupplement, tom.* 13. *for* 1778, p. 128. The Editor.

[*a*] The baſis of the calciform iron-ores, is either the *black* or *blackiſh brown* calx of iron, which is in ſome meaſure phlogiſticated and magnetic; or the *red* calx of iron, which

A. In form of calx, *Minera ferri calciformis pura.*

1. Pure.

a. Looſe and friable, *Minera ferri calciformis pura friabilis.* Martial ochre, *Minera ochracea.*

1. Powdry, *Ochra ferri,* is commonly yellow or red: and is iron which has been diſſolved by the vitriolic acid [*b*].

2. Concreted. Bog-ore.

a. In form of round porous balls.

b. More ſolid balls.

c. In ſmall flat pieces, like cakes, or pieces of money.

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is more dephlogiſticated, and not magnetic before torrefaction. *Kirwan.*

Among all iron ores, the moſt numerous are the calciform; and ſeem to be of a ſecondary formation, *viz.* they are formed by the depoſition and precipitation from waters, as appears by their mixture with various heterogeneous ſubſtances, many of which have belonged to organiſed bodies: they may be, therefore, looked upon as reſulting from the decompoſition of other iron-ores, made by *water* and the *aerial acid,* with which the moiſture that circulates through the earth is always impregnated. For this general acid attracts the phlogiſton contained in the true metallic ores, and in the martial æthiops it meets with; and this by a gradual and conſtant action, which is ſo much the more efficacious, as its power never ceaſes its exertion during the exiſtence of the metallic compound, until the whole is reduced into a calciform ſtate, or a martial *crocus.* According to Mongez, theſe calciform iron-ores may be properly divided into 1. the *ochreous* contained in this ſection: 2. the *cryſtallized*: 3. the *hæmatites*; and 4. the ſwampy, which will be treated of in the following notes. *The Editor, from* Mongez.

[*b*] See Note *c* to Section 340, where the *argillaceous* and the *bog,* or *ſwampy* iron-ores, are deſcribed. *The Editor.*

d. In ſmall grains.

e. In lumps of an indeterminate figure.

All theſe are of a blackiſh brown, or a light brown colour. They are found in lakes in the province of Smoland; and in marſhes at Fiellryggen, between the chain of rocks which ſeparates Sweden from Norway.

SECT. 336. (203.)

Indurated, pure, Calciform Iron-ores.

b. Indurated, *Minera ferri calciformis pura indurata.* The blood-ſtone, *Hæmatites* [*a*].

Of

[*a*] The name of *hæmatites*, or *blood-ſtones*, is not given to theſe ores on account of their external colour, for they are alſo *blue*, *yellow*, *brown*, and *micaceous*; but becauſe on being reduced to powder, or rubbed hardly, they produce a *red*, or *blood* colour. The yellow hæmatites, however, of Sect. 339, only give the *yellow* colour, when powdered.

They ſeem to be the reſult of the primitive iron-ores; and to have been formed like the ſtony concretions, and the earthy ſtalactites. They are fibrous, and ſtriated, like wood: ſome are formed in concentric layers, in oblong ſticks, or ſmall rods, in diverging radiations, and forming incruſtations to other extraneous bodies; generally they are of a hard conſiſtence; and ſome ſo much as to ſtrike fire on being ſtruck with hard-ſteel. The blackiſh hæmatites of Sect. 337. have a glaſſy ſhining fracture. The red ones of Sect. 338. to which the name of hæmatites more properly belongs, have ſometimes a colour approaching to the *purple*: when they have ſome calcareous mixture in their ſubſtance, as often happens, they make effervescence with acids. But in general they contain ſome little *argill*, and *manganeſe*. The hæmatitical

1. Of an iron colour, *Hæmatites cæruleſcens.*

This is of a blueiſh-grey colour; it is not attracted by the load-ſtone, yields a red powder when rubbed, and is hard.

a. Solid, and of a dim appearance when broken.

b. Cubical, and of a ſhining appearance when broken.

c. Fibrous *(Sädig.)*, is the moſt common *Torrſten* of Sweden.

d. Scaly (iron glimmer), the *Eiſenram* of the Germans.

This is for the moſt part as if it were teſtaceous, though the ſcales go acroſs the ſtrata of the ſtone. It is found at Jobſbo, at Norrberne in Dalárne, and Reka Klitt, in the province of Helſingland.

1. Black, from Gellebeck, in Norway.

2. Blueiſh-grey, from Reka Klitt.

When this is found together with marcaſite, as at Sandſwar in Norway, it is not

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tical ores are not magnetic before torrefaction; but they become black, and magnetic, by fire.

Theſe ores are productive of very good iron; and are found in great abundance in the province of Galiza, in the kingdom of Spain. The inhabitants of Compoſtelle, which is the capital town, make a good commerce of thoſe hæmatites of the hardeſt kind, for the burniſhing gold leaves, and various metals, therewith. Thoſe I have ſeen employed to theſe uſes were of the dark-blue kind, ſomewhat ſimilar to black-lead. But there are many other parts in Europe, where theſe ores are plentifully found; and in ſome places they form whole mountains: they afford from 40 to 80 *per cent.* of metal. *The Editor, chiefly from* Kirwan, Mongez, *and* Bomare.

only attracted by the loadſtone; but is of itſelf really a loadſtone. Sect. 343.

e. Cryſtalliſed [*b*].

1. In octoédrical cryſtals.
2. In polyédrical cryſtals.
3. In a cellular form, from Moſsgrufvan, at Norberg in Weſtmanland.

Theſe varieties are the moſt common in Sweden, and are very ſeldom blended with marcaſite, or any other heterogeneous ſubſtance, except their different beds.

[*b*] The moſt extraordinary iron ores of this kind, both on account of their forms, and of their various and brilliant colours, are found in the iſland of Elba, near the coaſt of Tuſcany. The cryſtallized ores are the moſt common, the pureſt, and the moſt beautiful; and no where elſe ſimilar ſpecimens have been found. They exhibit various gradations of the fineſt colours, as *red*, *violet*, *blue*, *green*, *yellow*, *brown*, *black*; and look, according to Coudrai's expreſſion, like ſo many cluſters of precious *emeralds*, *ſapphires*, *diamonds*, *rubies*, and *topazes*. I beheld, indeed, with aſtoniſhment, ſome of theſe ſpecimens, for the firſt time, on a mantle ſhelf of a private houſe at *Porto Longone*, where I touched on my ſailing to Italy, at the end of 1755, ſoon after the earthquake of Liſbon; and have ſeen ever ſince many ſpecimens of the kind in various collections; but they loſe great part of their brilliancy on being expoſed to the moiſture of the atmoſphere. Theſe ores have no other mineralizer, but the *aerial acid*, as E. Pini and Mongez aſſert, againſt the opinion of Coudrai, who pretends that they contain Sulphur. Beſides theſe cryſtallized ores, there are in the mines of Elba, various other iron-ores, ſuch as of the *hæmatite kind*, the *ochreous*, the *magnetical*, the *ſwampy*, and the *ſandy ones*. The whole iſland ſeems in fact to be a group of iron-mountains: its ores in general produce the beſt kind of malleable iron: and very great advantages would ariſe from theſe mines, if more ſkilful managers were employed in conducting their works. *The Editor, from* E. Pini, Coudrai, Mongez, *and* Ferber's *obſervations*.

It

It is remarkable, that, when theſe ores are found together with marcaſite, thoſe particles, which have laid neareſt to the marcaſite, are attracted by the loadſtone, although they yield a red or reddiſh-brown powder, like thoſe which are not attracted by the loadſtone.

It is likewiſe worth obſervation, that they generally contain a little ſulphur, if they are inbedded in a lime-ſtone rock, which, however, very ſeldom happens in Sweden; but I know only one ſuch inſtance, *viz.* at Billſio, in Soderberke, in the province of Dalarne. Sect. 345.

SECT. 337. (204.)

Black Hæmatites.

2. Blackiſh-brown bloodſtone, *Hæmatites nigreſcens.* Kidney ore.

This yields a red-brown powder when it is rubbed; it is very hard, and is not attracted by the loadſtone.

a. Solid, with a glaſſy texture, from Weſterſilfverberget, in the province of Weſtmanland.

b. Radiated.

c. Cryſtalliſed.

1. In form of cones, from Siberia.
2. In form of concentrick balls, with facets.

Theſe are very common in Germany, but very ſcarce in Sweden.

SECT. 338. (205.)

Red Hæmatites.

3. Blood-red, *Hæmatites ruber.* Red kidney ore.

a. Solid, and dim in its texture, from Weſterſilfverberget, in Weſtmandland.

b. Scaly. The *Eiſenram* of the Germans. This is commonly found with the iron-coloured iron-glimmer (Sect. 336. *d.* 1.), and ſmears the hands.

c. Cryſtallized.

1. In concentrick balls, with a flat or facetted ſurface.

SECT. 339. (206.)

Yellow Hæmatites.

4. Yellow bloodſtone, *Hæmatites flavus.*

a. Solid.

b. Fibrous, from Lammerhof, in Bohemia [*a*].

SECT.

[*a*] This yellow blood ſtone, when reduced into powder, retains the ſame colour it had before: as has been already remarked in the note [*a*], to Sect. 336, p. 724. *The Editor.*

The varieties of the colours in the blood ſtones are the ſame as thoſe produced in the calces of iron, made by *dry* or *liquid* menſtrua, and expoſed to different degrees of heat. *The Author.*

See

SECT. 340. (207.)

Heterogeneous iron-ores.

2. Iron in form of calx, mixed with heterogeneous ſubſtances. *Minera ferri calciformis heterogeneis mixta.*

a. With a calcareous earth. White ſpathoſe iron ore. The *Stahlſtein* of the Germans. See Sect. 36 [*a*].

With

See the note to Section 248. upon the ſucceſſion of colours exhibited by iron, when it is growing hot. *The Editor.*

Yellow ochres are diſtinguiſhed from clays, by containing a larger portion of martial particles; thoſe that become brown and magnetic by calcination, belong to this ſpecies. Sometimes the ferrugineous particles are mixed with argill, and calcareous, or muriatic earths; and then theſe ochres effervеſce with acids. Kirwan, Sp. 8.

[*a*] The *ſtharſtein*, or *Weiſs Eiſen Spath* of the Germans, is whitiſh, when freſh dug; but it becomes *grey* afterwards, then *brown*, at laſt *reddiſh*, *yellowiſh*, and *black*. It is either amorphous, or rhomboidal; is frequently tranſparent, and of a *lamellar* texture, or *ſcaly*, *granular*, or *cellular*. Sometimes it aſſumes a *ſtalactitical* form, and ſometimes is found in a *powdery* ſtate; in this laſt caſe it is of a brown-blackiſh colour; is frequently interſperſed with *quartz*, *pyrites*, *ſhoerl*, *zeolyte*, *mica*, and *aſbeſtos*. It will not give fire with ſteel, unleſs theſe foreign ſubſtances be ſtruck.

Its ſpecific gravity is from 3,600 to 3,895, or 4,000. It effervеſces feebly with acids, particularly when pounded and heated. It is ſcarcely ever magnetical before calcination; but, if heated, it decrepitates, grows black, becomes magnetic, and loſes from 15 to 40 *per cent.* of its weight. 100 parts of this ore from *Eiſenartz* in *Stiria* afford, according to

b. With a ſiliceous earth. The martial jaſper, or ſinople. Sect. 108. [*b*].

With

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to Bergman, 38 of brown calx of iron, 24 of white calx of manganeſe, and 38 of mild calcareous earth. That of *Weſt Silvretberg* contains 22 of the ſaid calx of iron, 28 of manganeſe, and 50 of mild calcareous earth.

N. B. The aerial acid is not only united to this laſt earth, but alſo to the metallic calces.

When this ore bears a ſtalactitical appearance, and is very white, it is called *Flos Ferri*, and *Eiſen Bluth*. This affords 27 *per cent.* of reguline iron, according to Rinman; and conſequently 35 of the brown calx. *Editor, from* Kirwan, Sp. 5.

Beſides the *ſtahlſtein*, mentioned by the author, there is a red calcareous iron ore found in many parts of England, in a looſe form. It effervesces ſtrongly with acids, and is uſed as a pigment. *Kirwan*, Sp. 14.

[*b*] Beſides the two ſiliceous combinations, mentioned by the author in theſe two laſt articles, the *jaſper*, *garnet*, and *tropp*, (which laſt will be mentioned in the Appendix among the *volcanic productions*), and various other compound ſubſtances, contain iron. There is found, principally in France, a *black*, *heavy*, *unmagnetic* ſand, of the ſiliceous kind, which is ſaid to contain *iron* and *zinc* in great quantity.

The *black ſand* from Virginia contains about half its weight of iron, and is magnetic. Its ſpecific gravity is=4,600, but its compoſition has not yet been diſcovered. *Kirwan*, Sp. 6.

It appears, by the account inſerted in the Philoſ. Tranſactions for 1763, p. 56, that there are very large quantities of this *ſand-iron-ore* in Virginia, perhaps as large as of any other kinds of iron-ore. It is ſo pure, that it required a mixture of *bog-ore*, or of *ſlags* from other ſmeltings, to reduce it to a metallic form. The iron and ſteel produced from it, was above 60 *per cent.* (or 50 from 85): the quality both of the *iron* and of the *ſteel*, made out of this ore, was extremely good, and two ſmall bars of the ſame were ſent, as a ſample, to the Muſeum of the Royal Society of London.

Large

c. With a garnet earth. Garnet and cockle, or ſhirl. Sect. 115 to 123.

d. With an argillaceous earth. The bole. Sect. 134 to 136. [*c*].

With

Large ſtrata of black-ſand iron-ore are found in various places of Portugal, even at a conſiderable diſtance from the ſea-ſhore, and from any running waters; a very great part of this black-ſand is attracted by the magnet; but I do not know, whether its component parts have ever been properly examined. *The Editor.*

Baron Born, in his letters from Hungary, quoted by Mr. Kirwan, mentions a blue cryſtallized iron-ore, which he ſays is a *ſhoerle* over-loaded with iron. *See alſo the note to p.* 212.

The ſame Mr. Kirwan, at p. 143 of his *Elements of Mineralogy*, ſpeaks of a ſiliceous ſand, conſolidated by ſemi-phlogiſticated calx of iron, which does not crumble into ſand when powdered. It is generally of a *brown* or *black* colour; but grows *reddiſh* or *yellowiſh*, and moulders by expoſure to the air. Its ſpecific gravity is from 2,800 to 3,600: it gives fire with ſteel, and does not effervesce with acids, unleſs it contains teſtaceous particles, as it frequently does, and is even often covered with ſhells.

He adds, that the agglutinating power of ſolutions of iron has been ſhewn by a ſtony concretion of this ſort, that had been long buried in the ſea, and is mentioned in a paper of Mr. Edward King, inſerted in the *Philoſ. Tranſactions* for 1779, p. 35. Mr. Rinman has found, by experiment, that dephlogiſticated calces of iron, and particularly its ſolutions made by mineral acids, have no binding power; on the contrary, they only make looſe concretions. *Kirwan.*

[*c*] The argillaceous iron-ores may be diſtinguiſhed into two varieties, namely, thoſe found in mountains and high lands, and thoſe found in ſwampy grounds, and low lands overflown with water; both are deſtitute of metallic luſtre, but very weighty, and ſome of them, when dry, abſorb water like clay.

The Highland ochraceous-ores of the argillaceous kind are either of a *yellow*, *red*, *brown*, or *greyiſh* colour; are friable,

e, With a micaceous earth. Mica. Sect. 65. [*d*].
f. With manganeſe. [*e*].

friable, looſe, and powdery, or in *grains*. They conſiſt chiefly of the calx of iron, in a looſe form, mixed with argill or clay, and frequently contain manganeſe: ſome in *France*, and in the neighbourhood of *Liege*, contain alſo the calx of *zinc*. They do not effervesce with acids, unleſs calcareous or muriatic earths be mixed with them; and never obey the magnet before calcination, and rarely after it.

Horn ſtone, overloaded with iron, belongs to this ſpecies.

Kinman mentions a *white* iron-ore, found in Kent, mixed with clay, or marl, which affords 47 *per cent.* of brittle iron; and is ſcarcely ſoluble in acids.

The *ſwampy* or *lacuſtris* iron-ore is friable, brown, browniſh, or black. It is found either in lumps, of an irregular ſhape, or in balls or in grains; and alſo in ſlender triangular priſms parallel to each other. It is mixed with argill, and extractive matter: becomes magnetic after calcination, by which it loſes about $\frac{1}{4}$ of its weight, whoſe greater part is water, and the remainder is aërial acid and volatile alkali. The crude ore affords about 30 *per cent.* of regulus; and, after calcination, about 50 *per cent.* The iron produced from this ore, chiefly that in Sweden, is of the *cold-ſhort* kind. Mr. Hielm found ſome ſorts of this ore, which contain 28 *per cent.* of manganeſe, *The Editor, from* Kirwan.

[*d*] When the *micaceous iron-ores* produce a red colour on being rubbed between the fingers, they belong to the *hæmatite kind*; and have been mentioned in note [*a*] to Sect. 336. But there are others that properly belong to this ſection; ſuch is, for inſtance, that kind of ſerpentine overloaded with iron, which may be called *muriatic iron-ore*; but it is ſeldom worked, if ever, to extract the metal. *The Editor, from* Kirwan.

[*e*] The iron ores, mixed with manganeſe, have been already mentioned in the two preceding notes [*a*] and [*c*]. *The Editor.*

SECT.

SECT. 341. (208.)

Native Pruſſian blue, or *Alkaline Iron-ore.*

g. With an alcali and phlogiſton. *Calx martialis phlogiſto juncta, et alcali precipitata.* Blue martial earth. Native Pruſſian-like blue.

1. Looſe or powdery, found among the turf in the levels of the province of Skone: alſo in Sax Weiſſenfels, and at Norvlanden in Norway, &c. [*a*].

SECT.

[*a*] This ore conſiſts of clay mixed with iron, and ſome unknown tinging ſubſtance. It is generally found in ſwampy grounds or bogs. At firſt its colour is white; but when expoſed to the air, it becomes either of a *white*, or of a deep *blue*.

When heated, it turns greeniſh, and emits a ſlight flame; afterwards turns red, and magnetic.

Is ſoluble in acids and alkalis, but the latter precipitate it from the former, and the former from the latter. The precipitate is at firſt greeniſh; but gradually aſſumes a white hue; and recovers the blue tinge, if it be ſteeped in vegetable aſtringents. The earth of *Benthnitz*, in *Sileſia*, ſeems to belong to this kind. It produces $\frac{1}{4}$ of its weight of iron.

Mr. Woulf found alſo this kind of ore in Scotland, on the ſurface of the earth, in the form of a fine white powder. The greateſt part of marſhy grounds, where the turf is found, generally contains ſome of this kind of iron ore. *The Editor, from* Kirwan *and* Mongez.

The *Terre verte*, called *Earth of Verona* and *Normandy*, is uſed as a pigment, and contains iron in ſome unknown ſtate, mixed with *clay*; and ſometimes with *chalk* and *pyrites*. *Alum* and

SECT. 342. (209.)

Cementing iron-ore. *Terras, cementum.*

b. Iron-ore with an unknown earth, which hardens in water.

Calx martis terrâ incognitâ indurescente mixta. Terras. *cementum* [*a*].

1. Loose or granulated, *Terra Pozzolana*, from Naples and Civita Vecchia in Italy. This is

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and *selenite* are also accidentally found with it. It is difficultly soluble in acids: is not magnetic before calcination, and becomes of a coffee-colour when heated. It is said to afford about 40 *per cent.* of iron.

N. B. If iron be precipitated from vinegar by the arsenical acid, the precipitate will be green, and will preserve its colour, though exposed to the air. Iron precipitated from the marine acid by lime-water is frequently green; and green fluors are known to derive their colour from iron. The molybdenous acid (Sect. 162.) gives also a green colour to iron; but this fades. *The Edit. from* Kirwan, Sp. 26.

[*a*] The *Traass*, or *Terras*, differs but little in its principles from *pozzolana*, which will be spoken of in the following note: but it is much more compact and hard, porous and spungy. It is generally of a *whitish yellow* colour, and contains more heterogeneous particles, as *spar*, *quartz*, *shoerl*, &c. and sometimes more of calcareous earth. It effervesces with acids, is magnetic, and fusible *per se*. When pulverized, it serves as a cement, like pozzolana. It is found in Germany and Sweden. Kirwan, pag. 81.

The

is of a reddiſh brown colour, is rich in iron, and is pretty fuſible [*b*].

Indurated,

[*b*] The *Terra pozzolana* is a volcanic product, compoſed of heterogeneous ſubſtances, thrown out from the burning mouths of volcanos, in the form of aſhes; ſometimes in ſuch large quantities, and with ſo great violence, that whole provinces have been covered with it at a conſiderable diſtance. In the year 79 of the common era, the cities of Herculaneum, Pompeia, and Stabia, although at the diſtance of many miles from Veſuvius, were, nevertheleſs, buried under the matters of theſe dreadful eruptions; as Bergman relates in his *Treatiſe of the Volcanic Products*.

This volcanic earth is of a grey, brown, or blackiſh colour; of a looſe, granular, or duſty and rough, porous or ſpungy texture, reſembling a clay hardened by fire, and then reduced to a groſs powder. It contains various heterogeneous ſubſtances mixed with it.

Its ſpecific gravity is from 2,500 to 2,800; and it is, in ſome degree, magnetic: it ſcarcely effervеſces with acids, though partially ſoluble in them.

It eaſily melts *per ſe*; but its moſt diſtinguiſhing property is, that it hardens very ſuddenly when mixed with $\frac{1}{3}$ of its weight of lime and water; and forms a cement, which is more durable in water than any other.

According to Bergman's Analyſis, 100 parts of it contain from 55 to 60 of *ſiliceous* earth, 20 of *argillaceous*, 5 or 6 of *calcareous*, and from 15 to 20 of iron.

It is evidently a *martial-argillaceous* marl, that has ſuffered a moderate heat. Its hardning power ariſes from the dry ſtate of the half-baked argillaceous particles, which make them imbibe water very rapidly, and thus accelerates the diſſication of the calcareous part; and alſo from the quantity and ſemiphlogiſticated ſtate of the iron contained in it.

It is found not only in Italy, but in France, in the Provinces of *Auvergne* and *Limoges*; and alſo in England, and elſewhere; *The Editor, from* Kirwan, pag. 80 *See what has been ſaid already by the* Author on this ſubject, *at the end of Sect.* 45, *pag.* 72.

Mention

2. Indurated, *Cementum induratum*, from Cologne [*c*].

This is of a whitiſh-yellow colour, contains likewiſe a great deal of iron, and has the ſame quality with the former, to harden ſoon in water, when mixed with mortar. This quality cannot be owing to the iron alone, but rather to ſome particular modification of it, occaſioned by ſome accidental cauſes; becauſe theſe varieties rarely happen at any other places, except where volcanos have been, or ſtill exiſt, in the neighbourhood.

SECT. 343. (211.)

B. Diſſolved, or mineraliſed Iron. *Ferrum mineraliſatum.*

1. With ſulphur alone.

a. Perfectly ſaturated with ſulphur, *Ferrum ſulphure ſaturatum.* Marcaſite. See Sulphur, Sect. 254.

b. With very little ſulphur. Black iron ore. Iron ſtone. *Minera ferri atra* [*a*].

This

[*c*] Mention has been made already in Sect. 132. p. 234, of a *colniſh pipe clay*, which, when indurated, may anſwer to this *cementum induratum*, ſpoken of in the preſent Section. But this I muſt leave to the judgement of the reader, as I have no other clear idea of this ſubſtance. *The Editor.*

[*a*] This is the *Stahlertz*, or *ferrum chalybeatum*, of Linnæus; *viz.* a brown calx of iron, mixed with iron in

This is either attracted by the loadſtone, or is a loadſtone itſelf, attracting iron; it reſembles iron, and yields a black powder when rubbed.

1. Magnetic iron-ore, *Minera ferri attractoria.* The Loadſtone, *Magnes* [*b*].

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in its metallic ſtate. Is of a dark ſteel colour, ſolid, compact, and ſhining in its fracture; ſcarcely gives fire with ſteel, produces a black powder; is magnetic, and, in ſome degree, malleable when red-hot. It affords from 60 to 80 *per cent.* of good iron. It is found at *Adelfors*, and *Dannemora* in *Sweden*: alſo in the *Iſle of Elbe*, and *North America*. Kirwan.

The *cryſtallized iron ore* belongs to this kind. It is in an octahedral, or cubic form: is the *ferrum teſſulare* of Linnæus, and the *minera ferri cryſtalli ſata* of Wallerius; it is ſomewhat leſs magnetic than the preceding ore; probably becauſe it contains leſs of the metallized iron. *Kirwan*, pag. 272.

[*b*] This differs but little in its appearance from the preceeding ore, but has leſs luſtre. It is either coarſe or fine grained. The coarſe grained loſes its power ſooneſt. It ſeems to contain a ſmall quantity of ſulphur, as it ſmells of it when red-hot. It is probable that it contains more particles of iron in its metallic ſtate than the preceding ore; but it is often contaminated with a mixture of *quartz* and *argill*. It is poſſible it may contain *nickel*; for this, when purified to a certain degree, acquires the properties of a magnet. Its conſtitution has not yet been properly examined. *Kirwan*, Spec. 3.

The magnetical attraction ſeems to ſtand alone among natural phenomena. Philoſophers obſerve its effect with ſurprize and admiration, whilſt the moſt cautious and rational are obliged to confeſs that the cauſe is intirely unknown, as *Nicholſon* obſerves (Book 3. Sect. 2); but, although this cauſe be not felt nor perceived by any of our ſenſes, we are abſolutely compelled to allow the exiſtence of an extremely ſubtle matter, which is capable of producing this effect. Perhaps! time will diſcover, whether it be coercible by any other ſubſtance; or what is neceſſary to be done before it can be exhibited alone, or in a ſeparate ſtate. *The Editor.*

a. Steel-grained, of a dim texture, from Hogberget, in the pariſh of Gagnœf in Dalarne: It is found at that place almoſt to the day, and is of as great ſtrength, as any natural loadſtones are ever commonly found.

b. Fine-grained, from Saxony.

c. Coarſe-grained, from Spetalsgrufvan, at Norberg, and Kierrgrufvan, both in the province of Weſtmanland. This very ſoon loſes its magnetical virtue.

d. With coarſe ſcales, found at Sandſwœr in Norway. This is a pyritical *Eiſenman*, and yields a red powder when rubbed. Sect. 336.

SECT. 344. (212.)

2. Refractory iron-ore. *Minera ferri refractoria.*

This ore, in its crude ſtate, is attracted by the loadſtone.

a. Giving a black powder when rubbed, *Tritura atra.* Of this kind are [*a*],

1. Steel-grained, from Adelfors, in the province of Smoland.
2. Fine-grained, from Dannemora, in the province of Upland.

[*a*] Probably the *iron-blende*, deſcribed by Mr. Monnet, and mentioned by Mr. Kirwan in his Sp. 23, belongs to this kind of ore. This iron-blende is a ſtone of a grey iron colour, formed of diverging laminæ, of great hardneſs, and a metallic appearance; but is inſoluble in acids, and infuſible in the ſtrongeſt fire. Sometimes this ſtone contains arſenic; and in this caſe it blackens by expoſure to the air. *The Editor.*

Coarſe-

3. Coarſe-grained, from Kierrgrufvan, in the province of Weſtmanland.

This kind is found in great quantities in all the Swediſh iron mines; and of this moſt part of the fuſible ores conſiſt, becauſe it is commonly found in ſuch kinds of rocks as are fuſible: and it is as ſeldom met with in quartz, as the hæmatites is met with in limeſtone.

SECT. 345. (213.)

b. Red-grained Iron ore, Tritura rubra.

This iron-ore differs from the preceding, on account of its rubbing into a red powder, *tritura rubra*.

Theſe are real hæmatites, that are ſo far modified by ſulphur or lime, as to be attracted by the loadſtone [*a*].

1. Steel-grained, found in a deſerted mine at Billſio, in the pariſh of Soderberke in Dalarne.

[*a*] Theſe ores are very ſcarce in Sweden, for the moſt part of the Swediſh blood-ſtones are pure, as has already been ſaid, in the Sect. 336. They form that very profitable ore called in Swediſh *Torrſt n.* The Author.

The *Torrſten* conſiſts of a red calx of iron, mixed with a ſmall proportion of the brown ore; and is indurated. It is of a bright bluiſh-black, or yellowiſh-grey colour, and of a fibrous texture, ſhows a red trace when ſcratched, and is weakly magnetic before calcination. According to Rinman, it is leſs dephlogiſticated than hæmatites. *The Editor from* Kirwan, Sp. 10.

2. Fine-grained. Emery. This is imported from the Levant. It is mixed with mica, is ſtrongly attracted by the loadſtone, and ſmells of ſulphur when put to the fire [*b*].
3. Of large ſhining cubes, from Thomſensgrube at Arendal in Norway.
4. Coarſe, ſcaly. The *Eiſenglimmer* or *Eiſenman* from Gellebeck in Norway [*b*].

SECT. 346. (214.)

Iron mineraliſed, or mixed.

Iron is found mineraliſed and mixed with various foſſil ſubſtances.

Iron mineraliſed by ſulphur. *Martial Pyrites* [*c*].

With

[*b*] Emery, according to *Kirwan*, *Sp.* 11, ſeems to be a mixture of the red and white calces of iron, with ſome unknown ſtony ſubſtance, perhaps *tripoli* (Sect. 143); it ſcarcely yields in hardneſs to any ſubſtance, except diamond.

The beſt ſort is of a dark grey colour, but becomes brown; and in great meaſure magnetic by calcination.

Other ſorts are of a reddiſh ruſty white, or yellowiſh colour.

Its ſpecific gravity is from 3,000 to 4,000.

It is never uſed as iron ore, nor is its proportion of iron well known. *The Editor.*

[*c*] The *martial Pyrites* are ſtony concretions of *ſulphur*, *clay*, and *calx* of iron; ſo hard as to give fire with ſteel, from whence their name is derived. There are two principal varieties of them; the firſt is,

The

With arſenic, *Ferrum arſenico mineraliſatum*; Called Miſpickel by the Germans, and Plate Mundic in Cornwall [*d*].

With

The pale yellow pyrites, which are real iron ores, containing from $\frac{1}{8}$ to $\frac{1}{3}$ of ſulphur, and from $\frac{1}{8}$ to $\frac{1}{3}$ of iron; the remainder is *argill* and *ſiliceons* earth, combined with each other, and the iron is in a ſemi-phlogiſticated ſtate.

They are of a yellow or grey colour, and of a globular, or cubic ſhape, internally radiated, and ſometimes lamellar; commonly are partly ſoluble in *nitrous acid* with effervescence; and ſlowly in the *vitriolic*; with which they form alum. *See Sect.* 200.

They detonate ſlightly with nitre, and are very infuſible. Their ſpecific gravity is from 7,3000 to 4,912. See Sect. 254, and the following.

Some *pyrites*, inſtead of *argillaceous*, contain *calcareous* earth; theſe are common in *France*, and in them the iron is, according to *Monnet*, in a dephlogiſticated ſtate; *Pyrites* are frequently found in a ſtalactitical ſhape, and often form the matter of petrifications. They are alſo found mixed and interſperſed through almoſt every other ſpecies of ſtone, except *granite*. According to the ſame *Monnet*, thoſe pyrites which are of a *filamentous*, or *ſtriated* texture, contain the leaſt ſulphur; and thoſe of a *lamellar*, moſt: the laſt efflorescе difficultly, if at all; and are ſaid to contain from 25 to 35 *per cent.* of ſulphur. *Kirwan*, pag. 190.

[*d*] The *Miſpickel*, called *Speiſs* by the Bohemians, is in general of a bright white, reſembling a mixture of *ſilver* and *tin*; ſometimes, though rarely, variegated, like a pigeon's neck, and not eaſily altered by expoſure to the air. Its form is either granular, cuſpidated, cuneiform, priſmatic, or rhomboidal.

Is not magnetical before, nor after calcination; but when iron contains leſs than $\frac{1}{70}$ of arſenic, it is then magnetic; therefore, if the calcination of miſpickel be puſhed ſo far, the iron will remain magnetic.

Is ſoluble in acids, and affords arſenic by diſtillation, in the proportion of 30 or 40 *per cent.* and it ſometimes contains a ſmall proportion of *copper* and *ſilver*.

With ſulphurated arſenic.

Arſenical Pyrites [c].

With vitriolic acid. Martial vitriol, Sect. 207 [d].

It is frequently mixed with other metallic ores, and often found in indurated clay, quartz, ſpar, ſhoerls, &c. *The Editor from* Kirwan, *Spec.* 20.

[c] This iron-ore is in the form of white grey pyrites, or marcaſite; and is called by the Germans *Rouſh gelb kieſs*, *Giſt kieſs*, or *Arſenic ſtein*.

It is found either in ſolid compact maſſes of a moderate ſize, or in grains.

It gives fire with ſteel.

When burnt, it affords a blue flame, and an arſenical ſmell, like garlick.

By diſtillation it affords *orpiment*, or *realgar*.

It is not magnetic, either before or after calcination; and contains much more arſenic than ſulphur.

It is analyſed by digeſtion in *marine* acid, to which the *nitrous* muſt be gradually added; otherwiſe the ſulphur would be deſtroyed.

The *marine* acid will take up the *iron* and leave the arſenic; otherwiſe, if it be analyſed by ſolution in *aqua regia*, both the *ſulphur* and the *arſenic* will be diſſolved; but, on adding water, the *arſenic* will be precipitated, and the iron will remain in the ſolution. The *ſilver* if any will remain in the form of horn-ſilver. *The Editor from* Kirwan, *Sp.* 19 and 20.

[d] This is a *brown*, or *reddiſh-brown* pyrites, called *Minera ferri hepatica* in Latin, and *Waſſer Kieſs* in German. It is generally of a ſpherical ſhape, cryſtallized in cubic, rhomboidal, or other polyhedral forms, and has no metallic luſtre.

It difficultly gives fire with ſteel, and contains very little ſulphur, but much more iron than the yellow pyrites; and not unfrequently a mixture of *calcareous earth*. It is ſometimes magnetic before, and always after, calcination. It is incapable of vitriolization. The iron it affords is brittle. *Kirwan*, Sp. 18. Var. 2.

With

With phlogiſton. Martial coal-ore. Sect. 258. B. 1. 2. [e].

With other ſulphurated and arſenicated metals. See theſe in their reſpective arrangements [f].

SECT. 347. (215.)

Obſervations on Iron [a].

This metal enters into ſo many compoſitions, that they cannot all be poſſibly enumerated

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[e] This combuſtible iron-ore, already deſcribed in Sect. 258, is a kind of coal, of which there are the two varieties there mentioned. The *volatil* ſeems to contain *iron*, *plumbago*, and *coal*, intimately mixed; and the other burns with a languid flame, looſes about $\frac{1}{7}$ of its weight, and yields about 30 *per cent.* of iron. *Kirwan*, pag. 283.

[f] The combination of *ſulphurated* iron with *zinc*, generally called *Calamine*, will be treated hereafter among the ores of that ſemi-metal.

That with the *Tungſten* mentioned by the Author in his Sect. 210, will be treated on the article of Wolfram among the ſemi-metals.

And that with *Manganeſe*, will be alſo treated on the Sections upon this ſemimetal. *The Editor.*

[a] 1. Iron is employed in three different ſtates, each having its peculiar properties, by which they are each more particularly applicable to various purpoſes. The firſt is *caſt-iron*, the ſecond is *wrought* or *malleable iron*, and the third is called *Steel*.

According to Bergman, *caſt iron*, which may be called *unripe* or *raw-iron*, contains the ſmalleſt ſhare of phlogiſton. The malleable iron contains the greateſt quantity, and the *ſteel* a middling ſhare between both, neither ſo much as the

rated; it muſt therefore ſuffice to mention only thoſe, in which it makes the predominant part. This metal is found in animals and vegetables; and certain iron-ores ſeem to be of ſervice to the

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malleable, nor ſo little as the *caſt-iron*. This laſt is called alſo *Pig-iron*, and *Yetlin* in England.

2. The richeſt ores of iron are the compact and ponderous, of a browniſh, reddiſh-brown, or red colour. Some of theſe ores, in colour and appearance, do not ill reſemble iron itſelf; as the grey ores of Derbyſhire, and the bluiſh of the Foreſt of Dean in Glouceſterſhire. Moſt of the Swediſh ores are likewiſe of this kind. Others are blackiſh, brown, red, yellowiſh, or ruſty coloured, as have been deſcribed in the preceding Sections: theſe are the moſt common in England and Germany. There is one very ſingular ſpecies of a ſtriated texture, and of a pale yellowiſh or greyiſh colour, oftentimes white, and in ſome degree pellucid; which, although in its crude ſtate, promiſes nothing metallic; nevertheleſs, on being moderately calcined, diſcovers, by the deep colour it aſſumes, that it abounds in iron. Cramer informs us, that it gives out by fuſion, from 30 to 60 *per cent.* But ſome richer ores yield no leſs than 70 and 80 on the hundred.

3. Different kinds of iron-ore are found adhering, in ſome mines, to the tops of caverns, in form of icicles or ſtriæ, ſometimes irregularly cluſtered together, ſometimes hanging down like the briſtles of a bruſh; from whence the name of *Bruſh-iron-ore*. Other particular forms of the iron ſtone have occaſioned a variety of fanciful names, that are met with in ſome of the metallurgic writers.

4. The iron of Great Britain is made from three different kinds of ores: 1. From the iron-ore, called the *Lancaſhire ore*, from the county where it is found in greateſt abundance. This ore is very heavy, of a fibrous or lamellated texture; it is of a dark purple, approaching to a ſhining black; and, when reduced to powder, it becomes of a *deep red*: it lies in veins like the ores of other metals: 2. The bog-ore, which reſembles a *deep yellow* ochry clay, and ſeems to be the depoſition of ſome ferruginaceous rivulets, whoſe currents had formerly

the vegetable kingdom, as it is manifeſtly ſeen on the ground, around and under the heaps of looſe ſtones laid up on ſeparating the ore from the rock, at thoſe iron mines, where the ores are mixed with limeſtone.

With

merly been over the ſurface of thoſe flat marſhy plains. It lies in beds of irregular thickneſs, commonly from 12 to 20 *inches*, and very various in their breadths from ſide to ſide, never being of great dimenſions. 3. The iron-ſtones, however, have no regular appearance, and do not in the leaſt reſemble a metal in their external ſurface. They lie often in beds of great extent, like other ſtony matters, and are ſometimes ſtratified with ſeams of pit-coal, forming alternate layers.

5. The ores of iron are commonly calcined, previous to the fuſion, even the harder ones, though they ſhould contain nothing *ſulphureous* or *arſenical*, in order to calcine the hard adhering matrices, and render the maſſes ſoft enough to be eaſily broken into fragments of a convenient ſize for melting. After the mineral is duly prepared, it muſt be ſmelted in furnaces of large capacities, from 16 to 25 *feet* high, and from 10 to 14 wide: the moſt approved ſhape nearly reſembles that of a hen's egg, with the largeſt end undermoſt, below which is a ſquare cavity to contain the melted metal, and at the top a very ſhort vent about 20 *inches* in diameter. The inner wall is built of fire ſtone, which endures very ſtrong heat with little riſk of melting, and all the joints are cemented with mortar compoſed of ſand and clay. This is ſurrounded with more building, which deviates more and more from a circular form, and becomes a ſquare building of about 20 feet at the baſe, and gradually converges to the top.

6. Near the bottom is an aperture, for the inſertion of the pipe of a large bellows, worked by water, or by other machines that may produce a ſtrong current of air. Some very powerful ones I have ſeen in the iron works at *Colebrook dale*, and conſiſt of two iron cylinders, about two or more feet wide, whoſe piſtons are alternately moved by a ſmall fire engine; but Mr. Wilkinſon very ingeniouſly adapted to his

own,

With reſpect to the œconomical effects, iron is divided into *cold-ſhort*, *red-ſhort*, and *tough*; and the ores into *refractory*, *fuſible*, and thoſe that do not want any admixture; which depends

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own, a large vaulted receiver ſurrounded by water, which produces a very regular and uniform blaſt. Two or more holes are alſo left ready to be occaſionally opened at the bottom of the furnace, to permit, at a proper time, the ſcoria and the metal to flow out, as the proceſs may require. Charcoal, or coke with lighted bruſhwood, is firſt thrown in: and when the inſide of the furnace has acquired a ſtrong ignition, the ore is thrown in by ſmall quantities at a time, with more of the fuel; and commonly a portion of lime-ſtone is thrown alſo, as a flux. The ore gradually ſubſides into the hotteſt part of the furnace, where it becomes fuſed; and the metallic parts, being revived by the coal, paſs through the ſcoria, and fall to the lower part, or bottom of the furnace, where a paſſage is open for taking off the ſcum or droſs. The metal now, in ſtrong fuſion, is let out, by a tap-hole, into furrows made in a bed of ſand: the large maſs, which ſets in the main furrow, is called by the workmen a *ſow*, and the leſſer ones *pigs* of iron. *Chimney-backs*, *ſtoves*, *garden-rollers*, &c. are formed of this rough metal, taken out of the receiver with ladles, and caſt into moulds made of fine ſand.

7. The quantity of fuel, the additions, and the heat, muſt be regulated, in order to obtain iron of good quality; and this quality muſt likewiſe, in the firſt product, be neceſſarily different, according to the nature of the parts that compoſe the ore.

8. Two or 3 *tons*, *viz.* 4, or 6,000 pounds weight of iron, are now run off in 24 hours, at ſome large furnaces, after the application of the large bellows; whilſt ſcarcely an hundred weight could be obtained in a day before that application; becauſe a large quantity of the metal was left in the droſs; hence, in ſome places, the flags of different ores, left by old operators in former times, are now re-melted to advantage along with freſh ore; and, on account of the richneſs of theſe old flags of different ores, ſome people have been miſled

pends on accidental circumſtances, and the method of working.

Although iron is commonly mixed in the different kinds of earths; yet it cannot be aſ-

ſerted

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miſled into the opinion, that the metal was regenerated in them.

9. Peat and turf has been found to anſwer tolerably well, mixed with charcoal, for the ſmelting of iron-ores; but I am informed, that the attempt I mentioned of its uſe at p. 485, has at laſt been found not to anſwer the expectations that had been conceived from the firſt trials. *Pit-coal*, if applied to the ſame purpoſe, renders the *iron* hard and brittle; but this inconvenience is prevented, by previouſly coaking the coal, and employing it in the ſtate of true *coak*. Cramer, in his *Art of Aſſaying*, p. 347. ſays, that *pit-coals*, *kennel-coals*, and *Scotch-coals*, *which burn to a white-aſh like wood*, and abound more in bitumen, may be uſed in the firſt fluxion of the iron from its ore; and if the iron proves not ſo malleable as required, this property may be given to it, by melting the metal a ſecond time with wood.

10. The beſt *caſt-iron*, or *raw-iron*, as much freed from heterogeneous matters, as the uſual proceſs of ſmelting can effect it, is not at all malleable, and ſo hard as perfectly to withſtand the file.

11. In general the impure caſt iron, as run from the ore, is melted down a ſecond time in another furnace, intermixt with charcoal. A ſtrong blaſt of air being impelled on the ſurface of the metal, its fuſion is remarkably promoted; the iron thickens into a maſs called a *loop*, which is conveyed under a large hammer raiſed by the motion of a water-wheel. The iron is there beaten into a thick ſquare form, is then heated again until almoſt ready to melt; and is forged: by a few repetitions of this proceſs, it becomes compleatly *malleable*, and is at length formed into bars for ſale.

12. Iron in this ſtate of *malleability*, is much ſofter than before, and of a fibrous texture. But if it is ſtill crude and brittle, after the above proceſs, it ſhews that there have remained heterogeneous matters, being hidden in its interſtices, which muſt be expelled; for this purpoſe the iron muſt be

ſtratified

ſerted with Becher, that iron may be melted out of every earth, by adding only a phlogiſton; ſince in that caſe this metal might alſo be got out of *Muſcovy* glaſs, *pure quartz*, *chalk*, *white*

ſtratified with charcoal-duſt within a proper furnace, heaped up in good quantity in *ſtrata*; then the fire muſt be blown pretty ſtrongly, ſo as to bring it to a fuſion, which is to be helped by the addition of fuſible ſcorias, or of ſand. The fire muſt not be much greater than neceſſary to make all theſe melt as equally as poſſible; to obtain this end, the melted maſs muſt be agitated here and there with poking rods of wrought iron, in order to make every part feel alike the action of the fire and air; and the increaſing ſcorias taken out once or twice.

13. In the mean time a great many ſparkles will be thrown out from the iron, which diminiſh the more as the iron comes nearer to the deſired degree of purity, but they never ceaſe entirely. The burning coals being then removed, and the ſcoria conveyed out of the fire, through a channel made for that purpoſe; the iron, by leſſening the violence of the fire, grows ſolid, and muſt be taken out red-hot, and tried by ſtriking it with a hammer. If it proves crude ſtill, let the melting be repeated; and when it is at laſt ſufficiently purified, it is to be hammered, and extended various ways, by making it red-hot many times over; this done, it will no longer be brittle, even when cold, as Cramer aſſerts.

14. Caſt iron has of late been brought into the malleable ſtate, by paſſing it through rollers, inſtead of forging it. Indeed this ſeems to be a real improvement in the proceſs, as well in point of diſpatch, as in its not requiring that ſkill and dexterity, which forge-men only acquire by long practice. If the purpoſes of commerce ſhould require more iron to be made, it will be eaſy to fabricate and erect rolling machines, though it might be impracticable to procure expert forge-men in a ſhort time.

15. This method was diſcovered by Henry Cort of Goſport, who obtained an excluſive privilege, granted by the king's patent. By this proceſs the raw or caſt-iron is freed from

white tranſparent fluor, &c. which probably has never yet been done.

Nature has beſtowed on Sweden an immenſe ſtore of iron ores; ſo that whole mountains, in Tornea and Lappmark in Lapland, conſiſt ſolely of a pure, and a very rich iron-ore.

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from the impurities, which are not diſcharged in the common methods of rendering this metal malleable; for iron is in itſelf a ſimple homogeneous metal; and all iron muſt become equally good, if it be purified from the heterogeneous and unmetallic particles that are any ways mixed with it.

16. The ordinary method of converting *caſt iron* into *malleable*, is, as have been ſeen, by employing great quantities of charcoal, which furniſhes phlogiſton, and remetallizes the particles, which are unmetallized, and mixed with the heterogeneous matters contained in the fuſed maſs: but in Cort's method there is no need of charcoal, inſtead of which, only ſea-coal is employed; becauſe the object is not to remetallize, but only to expell what is unmetallic; inſtead of endeavouring to reſtore the calcined parts with charcoal at a great expence, and ſtill leaving the buſineſs undone.

a. The iron is only heated and wrought ſimply by the heat of the flame, inſtead of being mixed with the burning fuel and aſhes, which are not eaſily diſengaged afterwards from the metal.

b. The method of ſqueezing it between the rollers, forces out the melted flags from the metallic pores, and brings its metallic fibres into a perfect ſolidity, and cloſe contact, ſo that they are obliged to cohere much more perfectly to each other, than by the interrupted and partial action of the hammer.

d. By the operation of being long ſtirred, the ſulphureous particles are more diſpoſed to be diſengaged, and are burned away in the form of blue ſparks; the metal then begins to curdle, and to loſe its fuſibility, like ſolder when it juſt begins to ſettle; the metallic particles meeting and coaleſcing together, much like the churning of milk, where the cream is ſeparated by the union formed between the

ore. Large veins of the ſame ore are likewiſe found, in almoſt every province of that kingdom, of ſuch a nature, that few countries can produce better or richer.

The magnetical power, with reſpect to its principles and origin, is no better underſtood than

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the fibrous particles of the cheeſe. The curdles formed into a connected maſs become what is called *loops*. The proceſs is as follows:

17. Five or 6 hundred weight of raw, *caſt-iron* (and even of *cold-ſhort* iron), is brought into a low fuſion, on a kind of hearth, or low furnace, in which it lyes to the depth of about 6 *inches*. One or two workmen continually ſtir this fuſed maſs, with long iron pokers, for about 4 or 5 hours. The heat is then lowered: the men faſhion the iron into narrow pieces of about 3 $\frac{1}{2}$ *feet* long, and 3 *inches* ſquare, with long knives or chiſels made for that purpoſe. They are then heated to the welding degree, and hammered to expel and ſcatter the unmetallic droſs. Theſe ſlabs are then formed to a wedge point at one end, in order to adapt them to be received between the rollers; they are malleable already, but they contain ſtill ſome droſs.

18. They are then heated again to the hoteſt welding heat in the air furnace: and immediately paſſed through large iron-rollers, turned by a water-wheel, or by horſes. If the end preſented to the rollers ſhould ſlip, inſtead of entering, a boy who ſtands ready, throws ſome ſand upon the iron, and it goes in eaſily. Much foreign and heterogeneous matter is ſqueezed out by the rollers; and the iron comes out in a purer malleable ſtate. The ſame heat will ſerve to paſs the iron through two ſets of rollers, which are groved ſo as to faſhion it into *nail-rods*, or other *forms*, according to the required purpoſes.

19. Various and repeated ſevere trials have been made in the Royal dock-yards of England, as I have been informed, in the preſence of perſons of knowledge and rank, to prove the *ſtrength*, *malleability*, and *ſoftneſs*, or *toughneſs* of this

than electricity, yet ſomething more with reſpect to its effects. Though both theſe qualities are now conſidered as different powers, they may perhaps in time be regarded as ſomething nearer allied to each other.

The

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new iron; and it has proved to be equal, and even ſometimes ſuperior to the beſt Swediſh iron. But I cannot conceive, indeed, by what ſingular fatality ſo great an improvement in manufacturing this moſt uſeful metal, has not yet been generally adopted by our Engliſh iron-maſters.

20. *Steel* is iron in an intermediate ſtate, between caſt-iron and malleable iron, which is ſoft and tough. The iron, run from ſome German ores, is found to be a good ſteel, when forged only to a certain point.

But the beſt ſteel is uſually made by cementation from the beſt forged iron, with matters chiefly of the inflammable kind. Two parts of pounded charcoal, and one of wood aſhes, is eſteemed a good cement. The charcoal duſt may be made of *bones*, *horns*, *leather*, and *hairs* of animals, or of any of theſe ingredients, after they are burned in a cloſe veſſel, till they are black; theſe being pulverized, and mixed with wood-aſhes, muſt be well mixed together. The iron bars ſhould be of pure metal, not over thick, and quite free from heterogeneous matters: their flexibility, both when hot and when cold, is a very good ſign thereof. A deep crucible, two or three inches higher than the bars, is to receive part of the cement, well preſſed at the bottom, to the height of 1½ inch; and the bars are to be placed perpendicularly, about one inch diſtant from the ſides of the veſſel, and from each other. All the interſtices are to be filled with the ſame cement, and the whole covered to the top with it; then a tile is applied to cover the veſſel, ſtopping the joints with thin lute.

21. The crucible is then to be put in the furnace, and a ſtrong fire is to be made that it be kept moderately red hot for 6 or 10 hours together; at the end of which time they will be found converted into ſteel. If the cementation be continued too long, the ſteel will become exceſſively brittle, incapable of being welded, and apt to crack and fly in

forging,

The magnetical power is not innate in the iron, but is collected into it by degrees, as is verified by experiments; it may be expelled, it may vaniſh, and become collected again, as it

forging. On the contrary, ſteel cemented with abſorbent earths is reduced to the ſtate of forged iron.

22. Steel is further puriſied, for making the niceſt kinds of inſtruments, ſuch as *lancets*, *pen-knives*, *razors*, and *various pieces*, for the beſt kind of *watches*, *time-keepers*, or *chronometers*, and *Aſtronomical regulators*. This purification of ſteel, conſiſts in melting it again with a ſtrong, but regular, fire in a crucible, the better to free it from the heterogeneous parts, and little flaws, that may be contained in it. It is then called *caſt-ſteel*, when fuſed into bars; which name, however, does not imply that the pieces, for inſtance the *caſt-ſteel razors*, have been really caſt in their preſent ſhape; for they muſt be forged from the bar, after it is caſt. The fuſion muſt have been perfect, ſo that the metallic parts be rendered uniform. The metal diminiſhes a little by this proceſs, for a bar of common ſteel 36 inches long, will afterwards produce another only of 35; if properly fuſed and purified.

23. The *caſt-ſteel* will not bear more than a *red heat*; otherwiſe it runs away, like ſand under the hammer, if the heat is puſhed to the *welding degree*. Dr. Watſon ſays, that this manufacture of caſt ſteel was introduced at Sheffield only about 40 years ago, by one Waller. I knew this man, who was ſtill living about the year 1765; he dwelled at St. Bartholomew's cloſe, and was a galloon-wire drawer by trade. The difficulty of procuring ſmall cylinders of good ſteel, to flatten the wire for lace-work in his buſineſs, whoſe defect proceeded from the bad texture of the ſteel, ſet his imagination on the enquiry after a method of purifying the metal to a greater perfection: and he thought that a new fuſion of it was the moſt likely to accompliſh his views. After ſome trials, he at laſt ſucceeded; but it was ſoon known to others, who got the advantages for themſelves, of which ill fate the real inventor very bitterly complained till the end of his life. His own name was even forgotten, as one Huntſman practiſed this art to ſuch an extent, that *caſt ſteel* was known under his ſole name afterwards.

24. But

it were out of the air: ſince the natural loadſtones for the moſt part occur in ſmall veins to the day, whereas at a greater depth only refractory

24. But before this diſcovery, made by Waller in England, this kind of ſteel was made already in Germany, as Watſon aſſerts; and from thence ſome ſmall quantities were brought to England at a conſiderable price. Since that time this branch of buſineſs is carried on advantageouſly at Sheffield; for the manufactures there furniſh a great abundance of broken tools and old bits of ſteel, at *a penny* a pound, which, after fuſion and purification, ſell for 10 or 12 times as much.

25. It is a valuable property of iron, after it is reduced into the ſtate of ſteel, that though it is ſufficiently ſoft when hot or when gradually cooled, to be formed without difficulty into various tools and utenſils; yet it may be afterwards rendered more or leſs hard, even to an extreme degree, by ſimply plunging it, when red-hot, into cold water. This is called *tempering*. The hardneſs produced is greater in proportion, as the ſteel is hotter, and the water colder. Hence ariſes the ſuperiority of this metal for making mechanic inſtruments or tools, by which all other metals, and even itſelf, are *filed*, *drilled*, and *cut*. The various degrees of hardneſs given to iron, depend on the quantity of ignition it poſſeſſes at the moment of being tempered, which is manifeſted by the ſucceſſion of colours, exhibited on the ſurface of the metal, in the progreſs of its receiving the increaſing heat. They are the *yellowiſh-white*, *yellow*, *gold-colour*, *purple*, *violet*, *deep-blue*, and *yellowiſh-white*; after which, the compleat ignition takes place. They proceed from a kind of ſcorification on the ſurface of the heated metal.

26. A bar of clean white ſteel may be made to aſſume all the above colours at once, by placing one end in the fire, and keeping the other end out, which is ſuppoſed of a proper length to remain cold.

27. Theſe colours ſerve as ſigns to direct the artiſt in tempering this metal. For though ignited ſteel, ſuddenly quenched in very cold water, proves exceſſively *hard* and *brittle*; yet it may be reduced to the required degree of temper, by heating

fractory iron-ores are found. There is the ſame difference between an artificial magnet of Dr. Knight's, and a bar of ſteel, whether of the

it, till it exhibits a known colour. This is the method employed in this proceſs by the artiſts. As ſoon as the piece of ſteel is compleatly ignited, they plunge it in a very cold water; and as ſoon as it looſes its fiery appearance, they take it out, rub it quickly with a file, or on a plate covered with ſand, that it may have a white ſurface. The heat, which is ſtill within the metal, ſoon begins to produce the ſucceſſion of colours. If a hard temper is deſired, as ſoon as the *yellow tinge* appears, the piece is dipped again, and ſtirred about the cold water. If the *purple* appears before the dipping it, the temper will be fit for tools employed in working upon metals; if dipped while *blue*, it will be proper for ſprings, and for other inſtruments fit to cut all ſorts of ſoft ſubſtances; but, if the laſt *pale colour* be waited for, the ſteel will not be hard at all.

29. This proceſs ſhews, that the minuteſt particles of the metal are hurried by the fire into a violent motion among themſelves; and, if the heat be ſuddenly checked, they remain forcibly ſtretched againſt each other, and retained out of their natural poſition; of courſe, they are prevented from receeding or ſliding to another point of mutual contact, neither can the metallic texture be then allowed to adapt itſelf to another ſhape or poſition, and receive a new form. On this account, almoſt all ſoft metals, if capable of being well hammered, do not fail of becoming harder and ſtiffer after the operation; and their ſpecific gravities are accordingly increaſed, becauſe the ſame quantity of matter is then compreſſed into a leſſer volume; whilſt it is well known, that hard-ſteel is ſpecifically lighter than after it has been hammered, *viz.* in the proportion of 7,704 to 7,195, according to Muſſchenbroek.

30. It deſerves notice, that a piece of iron is rendered conſiderably warm by hammering, ſo as to even become red hot. It ſeems that phlogiſton is thereby ſqueezed out of the metal, and is immediately attracted or abſorbed by the ſurrounding air, to which it has the greateſt affinity; and being deprived of its own ſpecific heat; this laſt becomes *latent* in the metal. But after the iron has been compleatly

the ſame ſhape or not, as between a natural loadſtone, and a blackiſh blue iron-ore; whence it is ridiculous to inſiſt with a certain author, that

hammered once, it is aſſerted, that it cannot be rendered again *red hot* by the ſame operation, becauſe no further compreſſion can then be made.

31. Hard ſteel is the only metal that, being ſtruck ſlantwiſe with the ſharp edge of a flint, or of another hard ſtone, produces ſparks of fire. The minute particles of the metal are driven off with extreme rapidity, their phlogiſton is ſet looſe, inſtantly attracted by the air, whoſe *ſpecific heat*, or *fire*, ruſhes into the metallic particles, inflames, and burns them; and they become truly calcined into ſcoria, as may be ſeen when examined with a magnifier; for they are moſtly, as little hollow balls, about one hundredth of an inch in diameter, of black or greyiſh colours, like the cinders of a black-ſmith's forge.

32. The theoretic ſolution of the two laſt phænomena have been lately rejected by the *modern aerial, French Philoſophers*, who abſolutely deny the very exiſtence of what has been called *phlogiſton* ſince the time of Stahl; but, until they can give a more intelligible and a better grounded etiology of theſe facts, by the evident properties of *their airs*, every philoſopher remains at liberty to diſregard their oppoſition.

33. P. S. I had forgot to obſerve upon the text *l*, p. 719. that iron is often manufactured ſo as to be 150 times, and even above 630 times more valuable than gold. I lately weighed ſome common watch *pendulum-ſprings* at Mr. Tho. Wright's watch-maker to the King, ſuch as are ſold at *half a crown* by the London artiſts for common work; and ten of them weighed but *one* ſingle grain. Hence *one* pound avoirdupois (= 7000 gr.) contains *ten times* as many of theſe ſprings; which, at half a crown apiece, amount to 8750 *pounds ſterl.* The troy ounce of gold ſells at 4 pounds ſterling, and the pound (=5760 gr.) at 48 pounds ſterl. which gives 58 33 (or 58 pounds 6 ſhillings and 7 pence) for each pound *averdupois* of gold: and of courſe $\frac{8750}{58\frac{1}{3}} = 150$.

34. But the *pendulum-ſprings* of the beſt kind of watches, ſell at *half a guinea* each: and at this rate, the above mentioned value muſt be increaſed in the ratio of 1. to 4,2; viz.

that no iron-ore can be attracted by the load-ſtone, but what of itſelf contains ſome magnetical virtue.

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of *half a crown*, to *half a guinea*: which will amount to 36750 pounds ſterling; and this ſum, divided by the value of this *pound* of gold, gives above 630 to the quotient.

35. N.B. 2. I ſhould have noticed alſo at p. 750, that the attraction between the *iron* and the *load ſtone* is the ſureſt teſt to diſcover the preſence of this metal in any ore whatever; for there is not any other body but iron, that is attracted by the natural load-ſtone, or by the artificial magnet, which has the very ſame property, and is compoſed of hard ſteel, properly impregnated with the magnetic power.

36. But very few iron-ores are really attracted by the load-ſtone, before they have been made *red-hot*, as Cramer aſſerts. He directs, for this purpoſe, to reduce into powder the ore that is to be tried, by pounding it in a *braſs-mortar*, but never in an *iron-one*: the powder is to be put in a crucible, well covered and luted, adding to the powder a ſmall quantity of tallow: then being placed in a furnace, let it be made red-hot, for about one hour, in a ſtrong fire. When cold, the powder is to be extended upon a ſheet of ſmooth paper, and applying very near to it the load-ſtone, or the magnet; if there are any particles of iron, they will be attracted by, and will ſtick to it.

37. It is remarkable that iron, even adulterated with other metals, or ſemi-metals, without excepting arſenic, is not thereby rendered altogether unfit to be attracted by the natural or artificial load-ſtone; although the power of being attracted is leſſened, but not extinguiſhed, in proportion to the quantity of the extraneous matters.

38. Antimony however is the only metallic body, that can prevent this attractive force between iron and the load ſtone, as the ſame author remarks. (N 360 of *Art of Eſſaying Metals*: p. 141.) He adds alſo that *ſulphur* ſcarcely prevents the ſame attraction: but Maquer ſays poſitively, that ſulphur is alſo a ſubſtance, that can hinder the reduced iron from being attracted by the load-ſtone. *See the article* Molybdene *in his* Chemical Dictionary. It is rather odd, that ſo little notice has been taken by other mineralogical writers and philoſophers, of the action of theſe two ſubſtances on this general property of iron! *The Editor, from Bergman, &c.*

ORDER

ORDER THE THIRD.

Semi-metals.

SECT. 348. (221.)

Biſmuth, Tin-glaſs. *Biſmuthum*, *Marcaſita officinalis*, Lat. *Aſkbly*, Swed. *Wiſmuth*, Germ.

This ſemi-metal is [*a*],

a. Of a whitiſh yellow colour.

b. Of

[*a*] Biſmuth, or viſmuth, is the heavieſt of all the brittle metals, called ſemi-metals.

Its ſpecific gravity, according to Kirwan, is from 9,600 to 9,7000.

Nitrous acid, and *aqua regia*, diſſolve it perfectly.

The *vitriolic* acid muſt be boiled nearly to dryneſs, before it acts upon this ſemimetal: and

The *muriatic* acid only attacks its calx.

The quantity of phlogiſton, which reſiſts the action of menſtrua on it, is expreſſed by 57; and its power of retaining it, ranks it in the *ſeventh* place.

It melts at the heat of 494 degrees. *Bergman.*

Its ſolution by nitrous acid is cryſtalliſable, into quadrilateral pyramids. *Wallerius.*

The addition of pure water to the nitrous ſolution of biſmuth, precipitates its calx, and is the criterion by which this ſemimetal is diſtinguiſhed from all other metals.

This white calx, called *Magiſtery of Biſmuth*, is uſed by the fair ſex, as a paint to whiten the ſkin, and improve the complexion; which, however, it gradually impairs

b. Of a laminated texture, yielding under the hammer, and nevertheleſs very brittle.

c. Its ſpecific gravity to water is, as 9,700 : : 1000.

d. It is very fuſible, calcines and ſcorifies like lead, if not rather eaſier, and therefore it works on the cuppel. It is conſiderably volatile in the fire.

e. Its glaſs or ſlag becomes yellowiſh brown, and has the quality of retaining ſome part of the gold, if that metal has been melted, calcined, and vitrified with it.

f. It may be mixed with the other metals, except cobalt and zink, making them white and brittle.

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very remarkably. Strong ſmells, ſulphureous vapours, and very odorous emanations, immediately turn this coſmetic into a brown or black colour.

The magiſtery of biſmuth appears to have indeed ſome latent corroſive quality; and, when freely uſed as a coſmetic, muſt be very hurtful. It gradually impairs the natural complexion; and leaves, for old age, a coarſe, diſagreeable, and ugly ſkin.

It is ſaid that this magiſtery produces a whiteneſs in *grey*, *reddiſh*, *yellow*, or *other coloured* hair; but the contrary is evinced by experiment; for it changes the whiteſt flaxen hair firſt to a *yellowiſh*, then to a *yellowiſh*-brown, afterwards to a *dark-brown*, and at laſt to a *blackiſh colour*.

The tryal may be made in two ways; by boiling the hair in water, along with the magiſtery; or by applying the magiſtery mixed with pomatum, or hanging the hair in the ſun greeſed with it. The oftener this is repeated, the darker will the colour be. We may therefore judge from hence, that this magiſtery is leſs fit for the purpoſe of coſmetic, than any other, that ever was recommended to the fair ſex.

Moſt

g. It is ſoluble in aqua-fortis, without imparting to it any colour; but to the aqua-regia it gives a red colour, and may be precipitated out of both theſe ſolutions with pure water, into a white-powder, which is called *Spaniſh white*. It is alſo precipitated by the acid of ſea-ſalt, which laſt unites with it, and makes the *Viſmutum corneum*.

h. It amalgamates eaſily with quickſilver. Other metals are ſo far attenuated by the biſmuth, when mixed with it, as to be ſtrained or forced along with the quickſilver through ſkins or leather.

SECT. 349. (222.)

Native Biſmuth.

Biſmuth is found in the earth.

A. Native, *Viſmutum Nativum* [*b*].

Moſt metallic ſubſtances unite with biſmuth, and are rendered more fuſible by its addition.

It is uſed in making *pewter*, *printers types*, *ſolder*, &c.

The great fuſibility of the mixture of biſmuth, tin, and lead, renders it of a great uſe in making collars for the axles of ſome mechanical inſtruments to run in. *The Editor from* Neumann, Nicholſon, &c.

[*b*] This is the moſt common of all native metallic ſubſtances; and is generally found either in cubes, or octagons; or of a dendritical form; or in that of thin laminæ, inveſting the ores of other metals, particularly thoſe of Cobalt; from which is eaſily diſtinguiſhed and ſeparated by its great fuſibility.

It is ſaid to be ſometimes found alloyed with ſilver. In ſuch caſe it may be eaſily ſeparated by its ſolution in nitrous

This reſembles a regulus of biſmuth, but conſiſts of ſmaller ſcales or plates.

1. Superficial, or in cruſts.

2. Solid, and compoſed of ſmall cubes.

This is found in, and with, the cobalt ore, at Schneeberg in Saxony, and other foreign places: Likewiſe along with the copper ore, at Nyberget in the pariſh of Stora Skedwi, in the province of Dalarne.

SECT. 350. (223.)

Biſmuth Calciform.

β. In form of calx, *Viſmutum calciforme.*

1. Powdry or friable, *Ochra viſmuti.*

This is of a whitiſh yellow colour: it is found in form of an efflorescence, to the day, at Los, in the province of Helſingland.

It has been cuſtomary to give the name of *Flowers of Biſmuth* to the pale red calx of *cobalt*, but it is wrong; becauſe neither the calx of biſmuth, nor its ſolutions, become red, this being a quality belonging to the *cobalt* [*c*].

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acid; for, by the addition of water, the biſmuth only will be ſeparated, and any other metal will remain in the ſolution.

Native biſmuth is of a yellowiſh white colour; and ſo fuſible as to melt at the flame of a candle, when pure. *The Editor from* Kirwan *and* Wallerius.

[*c*] There are *greeniſh-yellow* calces of biſmuth, frequently found with glittering particles, interſperſed through ſtones of various

I have ſeen a radiated criſtalliſation of a metallic appearance, which was found at Schneeberg, and was likewiſe called *Biſmuth Flowers*; but in the ſmall trial I was permitted to make on it, it did not diſcover the leaſt marks of biſmuth, but anſwered rather to *zink*, if *zink* may be ſuppoſed to exiſt in a native ſtate.

SECT. 351. (Additional.)

Biſmuth mineralized by vitriolic acid.

This ore is called *Wiſmuth Bluth* by the Germans. It is ſaid to be of a yellowiſh, reddiſh, or variegated colour; and to be found mixed with the calx of biſmuth, incruſting other ores. From *Kirwan*, p. 334.

SECT. 352. (224.)

(Mineraliſed Biſmuth, *Viſmutum ſulphure mineraliſatum* [*d*].

This is, with reſpect to colour and appearance, like the coarſe teſſellated potter's lead ore;

various kinds; ſilver, and other metals, are alſo found in this kind of ore: from all which it is ſeparable by ſolution in *nitrous acid*, as has been ſaid in note [*a*] to p. 759. Kirwan, p. 333.

[*d*] This is chiefly found in Sweden; is of a bluiſh grey colour, of a lamellar texture, and teſſellar form like galena; but much heavier.

It

ore; but it conſiſts of very thin ſquare plates or flakes, from which it receives a radiated appearance, when broken croſswiſe.

1. With ſulphur, *Viſmutum ſulphure mineraliſatum.*

a. With large plates or flakes, from Baſtnas at Riddarſhyttan, Baſringe and Stripas in Weſtmanland.

b. With fine or ſmall ſcales, from Jacobsgrufvan at Riddarſhyttan, and the mines at Los, in the pariſh of Farila, in Helſingland.

SECT. 353. (225.)

2. *Viſmutum ferro ſulphurato mineraliſatum.*

2. With ſulphurated iron.

a. Of coarſe, wedge-like ſcales, from Kongruben, at Gellebeck in Norway [*e*].

It ſometimes preſents parallel ſtriæ like antimony; and its colour is variegated. It is ſaid to contain alſo *cobalt* and arſenic.

This ore is very fuſible; the ſulphur moſtly ſeparates in ſcorification; and it is ſoluble in nitrous acid. *From* Kirwan *p.* 334.

[*e*] This mineraliſed biſmuth ore yields a fine radiated regulus; for which reaſon it has been ranked among the antimonial ores, by thoſe who have not taken proper care to melt a pure regulus, or deſtitute of ſulphur, from it; while others, who make no difference between regules and pure metals, have ſtill more poſitively aſſerted it to be only an antimonial ore. *The Author.*

In Schneeberg they have what is called *columbine* biſmuth, and *plumoſe* biſmuth; the former has its name from its color, the

SECT. 354. (Additional.)

Mineraliſed with Sulphur and Arſenic.

This ore of biſmuth is of a whitiſh-yellow, or aſh-colour [*f*]:

Has a ſhining appearance, and

Is compoſed of ſmall ſcales or plates, intermixed very ſmall yellow flakes.

It is of a hard and ſolid texture;

Sometimes ſtrikes fire with hard ſteel.

Has a diſagreable ſmell, when rubbed.

Does not effervesce with *aqua fortis:*

But is partially diſſolved by the ſame acid.

This ſolution, being diluted with water, becomes a kind of ſympathetic ink; as the words

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the latter from the texture. The latter is ſaid to contain a great qantity of cobalt. *Brunnich.*

In the *dry way* this ore is extracted from its ſtony bed, by mixing 2 parts of the pulverized ore with one of pounded glaſs, and one of calcined borax, melting the whole in a crucible lined with charcoal. *Kirwan*, p. 335.

[*f*] 1. There is alſo a grey biſmuth-ore, of the arſenicated kind, with a ſtriated form, found at Helſingland in Sweden, and at *Annaberg* in Saxony.

2. Another ore of biſmuth of the ſame kind, with variegated colours of *red*, *blue*, and yellow *grey*, is alſo found at *Schneeberg* in Saxony.

3. Striated with green fibres like an *Amianthus*, at Miſnia in Germany, and at *Gillebeck* in Norway.

4. With yellow-red ſhining particles, called *Mines de Biſmuth Tigrées* in French, at *Georgenſtadt* in Germany, and at *Annaberg* in Saxony.

5. The *minera Biſmuthi arenacea*, mentioned by Wallerius and Bomare, belongs alſo to the ſame kind of the arſenicated ores. *The Editor, chiefly from* Bomare.

written

written with it on a white paper, and dried, are not diſtinguiſhed by the eye; but, on being heated before the fire, they aſſume a yellowiſh-colour. This ore is found at *Rappolt*, and *Schneeberg* in Saxony. *Wallerius* and *Bomare*.

SECT. 355. (226.)

Obſervations on Biſmuth [g].

Although Mr. Pott has, in a ſeparate Treatiſe on biſmuth, ſhewn, that it is diſſolved without giving

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[g] Biſmuth, or tin-glaſs, in its external appearance, has a great reſemblance to *regulus of antimony* and *zinc*, differing little otherwiſe, than in the largeneſs of its plates or ſcales; and its contracting a yellowiſh caſt on the ſurface, when expoſed to the air. But as to its intrinſic properties, it is extremely different; melting far more eaſily, not evaporating ſo readily, being differently acted upon by acids, producing different effects upon other metallic bodies, &c.

When biſmuth is kept in fuſion, and is ſtirred, it ſoon calcines, gaining at the ſame time an increaſe in its weight of near half an ounce upon a pound.

The calx melts, on raiſing the fire a little, into a browniſh or yellowiſh glaſs, which promotes the vitrification of earths, and of the refractory metallic calces more powerfully: and corrodes and ſinks through common crucibles more readily, than glaſs of lead itſelf.

If biſmuth be mixed with gold or ſilver, a heat, that is but juſt ſufficient to melt the mixture, will preſently vitrify a part of the biſmuth, which having no action on theſe perfect metals, ſeparates and glazes the crucible all round.

It

giving any colour to the ſolution, and that it is precipitated with pure water; and, though the mine-maſter Mr. Brandt has likewiſe, in the *Acta Upſalienſia* for the year 1735, given an accurate hiſtory of the cobalt; we find nevertheleſs in ſome new authors ſuch a definition of biſmuth, as includes at the ſame time the principal characters of the cobalt, viz.

It melts a little later than tin; and ſeems to be the moſt fluid of all metallic ſubſtances.

When in fuſion it occupies leſs volume than in its ſolid ſtate; a property peculiar to iron among metals, and itſelf among the ſemimetals.

It emits fumes in the fire as long as it preſerves its metallic form. When calcined, or vitrified, it proves perfectly fixed.

Calx of biſmuth, long reverberated, does not, as ſome pretend, become *red* like the calces of lead. It ſcarcely retains even the form of a calx; for a part of the biſmuth is ſoon revived into its metallic appearance by the flame. None of the deſtructible metallic bodies is ſo eaſy of revival as this ſemimetal. If the veſſel be covered, and all inflamable matters excluded, vitrification is the only change that enſues.

Biſmuth cemented with ſulphur, readily unites with it, and melts eaſier than by itſelf; but on continuing the fire, they ſoon ſeparate again, the biſmuth falling to the bottom, and a ſulphureous ſcoria ſwiming on the ſurface.

Calx of biſmuth likewiſe, very eaſily abſorbs ſulphur, and forms with it a curious needle-form maſs, exactly reſembling antimony, contracting a reddiſh tinge externally on expoſure to the air. The quantity of ſulphur imbibed is leſs than half the weight of the calx; a part of the ſulphur having ſublimed, when the operation was performed in a retort, in that proportion.

Silver added to this concrete, melts with it in a very gentle heat, into a brittle regulus. Gold alſo unites with it, but requires a much ſtronger fire: the compound is brittle, in appearance like an ore, with here and there ſome ſtriæ or ſhining particles.

Copper

that of giving to glaſs a blue colour, and to tinge ſolutions red. This confuſion proceeds from the biſmuth being commonly found among cobalt ores, and not being ſeparated from it but by the way of eliquation; during which the cobalt, as being leſs fuſible, remains, and is by the workmen called *Viſmut graupe*, or Biſmuth grains.

This

Copper melts with it in a ſmall heat, with remarkable facility; and after they have been united, the compound continues to retain its extraordinary fuſibility. On the addition of lead to this compound, a new combination takes place; the copper and ſulphur ariſe to the ſurface in ſcoria reſembling an ore, whilſt the biſmuth and lead form a regulus at the bottom.

Zinc and biſmuth do not unite together, the zinc flowing diſtinct upon the ſurface, and burning as it does by itſelf.

Mercury forms with biſmuth an amalgam, which readily adheres to iron. If the iron, coated with the amalgam, be expoſed to the fire, the mercury exhales, and greateſt part of the biſmuth remains fixed upon the iron, which then looks as if it had been ſilvered.

If mixtures of biſmuth, with ſome other metals, particularly lead, be amalgamated, the lead is found to be ſo attenuated, as to paſs with the quickſilver through leather. On ſtanding, the biſmuth is thrown up to the ſurface in form of a dark-coloured powder, the lead remaining diſſolved in the quickſilver.

Equal parts of lead, tin, and biſmuth, form a blackiſh ſparkling compound, reſembling the ſmall-diced ores of lead.

The ſpecific gravity of a mixture of biſmuth and copper, is exactly the mean gravity of that of the two ingredients unmixed. But mixtures of it with iron are ſpecifically lighter than the ingredients ſeparately: whilſt mixtures of biſmuth with gold, ſilver, tin, lead, and regulus of antimony, are heavier than before by themſelves ſeparately.

Tin being too ſoft of itſelf for making veſſels and utenſils for common uſe, is generally worked with ſome additional

metallic

This error is excuſable in thoſe who do not pretend to maintain and vindicate their ignorance, it having been the fate of the ſemi-metals to be but very little examined. If the alchemiſts had not thought the quickſilver, antimony, and zink, fit for their purpoſes, we ſhould very likely have ſtill wanted many of thoſe

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metallic matters, of which biſmuth is one of the principal. This mixed metal is called *pewter* in England, and conſtantly miſtaken abroad for pure tin, being called by the name of this laſt metal. *See the* note N° 9 *to page* 643.

Biſmuth being eaſier to fuſe than lead or tin, is mixed with both to make a proper ſolder for each.

This ſemi-metal being reduced to powder, and applied, with the white of eggs, upon turned wood, makes it look as ſilvered, after it is dryed, and properly-rubbed over with a hard poliſher.

Biſmuth is preferable to lead for purifying gold and ſilver by cupellation, ſcorification, &c. For it more effectually promotes the deſtruction of the imperfect metals, and the vitrification of the earths, calces, or any refractory matters blended with them; as it procures a greater tenuity in the fuſion, than lead is capable of producing. In all the operations of this kind, where ſulphur makes one of the heterogeneous matters, biſmuth is of the greateſt advantage; namely, on account of its forming with that concrete an extremely fuſible maſs, whilſt lead combined with ſulphur, proves extremely refractory.

Biſmuth has been too often employed for the adulteration of quickſilver, as rendering a very conſiderable proportion of lead intimately united with it. One part of this laſt metal, mixed with an equal one of biſmuth, may be incorporated with three of quickſilver, without affecting its fluidity. Quickſilver thus adulterated is not only unfit for medicinal uſes, but even for the common mechanic purpoſes of gilding and ſilvering; as the workmen find in this caſe, that it leaves upon the gold or ſilver a livid leaden hue, which ſpoils the proper fine appearance of the work.

thoſe advantages which they afford both in medicine and common life.

Biſmuth, it is true, has likewiſe in its time been in ſome favour with adepts; but it ſoon loſt its credit: and was left to thoſe who contented themſelves with leſs proſpects than

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work. If the abuſe is diſcovered, the mercury may be purified by diſtillation; although it appears by the aſſertions of Boerhaave, that a very ſlight film is always acquired by the proceſs. *See the Note to p.* 592.

Some ſay that the biſmuth earth, or *caput mortuum* of biſmuth, may be employed for making blue glaſs, in the ſame manner, as calcined cobalt; but when this happens, it only proceeds from the accidental mixture of cobalt, which is ſometimes found naturally in the ores of biſmuth.

A tincture is drawn from the ore of biſmuth diſſolved in *aqua fortis*, which being mixed with a ſaturated ſolution of ſea-ſalt, and inſpiſſated, yields a reddiſh ſalt: its watery ſolution is the curious liquor, called the *Green Sympathetic Ink*, though there is a real impropriety in calling it *green*, where it is in fact a *red liquor*. If any words are written with this ink on white paper, the characters diſappear as ſoon as they are dry; but on holding the paper to the fire, they become *green* and legible; on cooling they diſappear again, and this repeatedly any number of times.

According to Bomare, the words written with this ſympathetic ink may alſo be rendered legible, by wetting them with a ſponge or pencil dipped in an aqueous ſolution of hepar ſulphuris.

The experiments ſucceed beſt, when the tincture, drawn from the calcined ore of biſmuth, is mixed with a ſolution of one fourth of its weight of ſea-ſalt; this mixture is then evaporated almoſt to dryneſs, and the reſiduum is diſſolved in water, which is then the ſympathetic ink. If the tincture be mixed with nitre or borax, inſtead of ſea ſalt, the characters will become *roſe coloured* when warmed; and if ſea-ſalt is afterwards paſſed over them, they will become *blue*; but if mixed with alkali ſufficient to ſaturate the acid, they change to *purple* and *red* colour by heat.

Biſmuth

than of making gold and the universal medicine; as to pewterers, tin-workers, and other tradesmen, who find their advantage in the fusibility of this semi-metal, and its giving colour and hardness to tin and lead.

SECT. 356. (227.)

3. Zinc, Spelter. *Zincum*, *Marchasita aurea*, *Zinethum*, Lat. *Spiauter*, Swed.

General properties of Zink.

This semimetal is distinguished from other metallic substances by the following qualities:

a. Its colour comes nearest to that of lead, but it does not so easily tarnish [*a*].

It

Bismuth is most commonly lodged in cobalt-ores; and, when they are of a *high red*, or *peach-bloom* colour, they are called *Bismuth bloom*, or *Flowers of Bismuth*. It was formerly believed, and some are still of opinion, that *Bismuth* gives to glass the same *blue-colour* as the cobalt does; because the dross which remains after the *Bismuth* has been melted out, called *Bismuth-grain* by the smelters, produces sometimes that effect. But, as no such grains or colouring earth remain from pure bismuth, it is plain that this quality must arise from something that was mixed with the bismuth, which undoubtedly is nothing else but some partial mixture of the cobalt ore, that was contained along with the bismuth. *Gellert's Metal. Chem.* pag. 61. *The Editor, chiefly from* Neumann, Lewis, &c.

[*a*] Zinc is the most malleable of all the semi-metals.

Its specific gravity is = 6862, according to Bergman; and Kirwan asserts it to to be from 6,900 to 7,240.

It

b. It ſhews a texture, when it is broken, as if it were compounded of flat pyramids.

c. Its ſpecific gravity to water is, as 6,000 or 7000 : : 1000.

d. It melts in the fire before it has acquired a glowing heat; but when it has gained that degree of heat, it burns with a flame of a changeable colour, between blue and yellow; and if in an open fire, the calx riſes in form of ſoft *white flowers* [*b*]; but if in a covered veſſel, with the addition of

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It melts at a lower heat than *copper* or *ſilver*; but at a higher degree than *lead* or *tin*, according to *Kirwan*, *pag.* 312. Bergman affirms its melting to be at the 699° of Fahrenheit's thermometer.

When broken it looks as if its whole texture was a compound of looſe cubical grains. *Gellert's* Metall. Chymiſt. chap. 7. p. 32.

It cannot be reduced into powder under the hammer like other ſemi-metals. When it is wanted very much divided, it muſt be granulated, by pouring it while fuſed into cold water: or filed, which is very tedious, as it ſtuffs and fills the teeth of the file. But if it be heated the moſt poſſible without fuſing it, Macquer aſſerts, that it becomes ſo brittle as to be pulveriſed in a mortar.

This property is very different from that of metals, which become more ductile by the action of fire.

The facets which the pigs of zinc preſent in their fracture, indicate that it is cryſtalliſable: and Mongez found that its cryſtallization conſiſts of bundles of ſmall quadrangular priſms, variouſly diſpoſed on all ſides, of a blue colour, which changes if expoſed to the air. *Fourcroy.*

[*b*] Theſe are called *Flowers of Zinc*, which are very fixed in the fire, and ſoluble in acids. *Kirwan.*

The calces of all metals and ſemi-metals may be reduced again into their metallic form, by the addition of proper phlogiſtic ſubſtances; but the white calx of zinc admits of no reduction. *Cramer.*

ſome

ſome inflammable ſubſtance, it is diſtilled in a metallic form; in which operation, however, part of it is ſometimes found vitrified. *e.* It unites with all the metals, except biſmuth, and makes them volatile [*c*]. It is however not eaſy to unite it with iron without the addition of ſulphur [*d*]. It has the

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[*c*] Zinc alſo does not mix in fuſion with Nickel, nor with Biſmuth. How carefully ſoever it be ſtirred and mixed with either of theſe, the zinc, when grown cold, is found diſtinct upon the ſurface, ſo as to be readily ſeparated by a blow.

It brightens the colour of iron almoſt into a ſilver hue; changes that of copper to a yellow, or gold colour, as mentioned pag. 676. and note [*g*] pag. 707. but greatly debaſes the colour of gold and deſtroys its malleability. One hundredth part of zinc renders this moſt ductile metal brittle and intractable. A mixture of equal parts of gold and zinc forms a very hard, white metal, which bears a fine poliſh, and was propoſed by Hellot for making ſpecula of reflecting teleſcopes, as it never ruſts nor tarniſhes when expoſed to the air.

It improves the colour and luſtre of lead and tin, rendering them firmer, and conſequently fitter for ſundry mechanic uſes. Lead will bear an equal weight of zinc, without loſing too much of its malleability.

Arſenic, however, which whitens all other metals, renders zinc black and friable; and when this mixture is made in cloſe veſſels, an agreeable aromatic odour is perceived on opening them. *Lewis.*

[*d*] Zinc, however, does not unite in the leaſt with ſulphur, or with crude antimony, which ſcorify all other metallic ſubſtances, except gold and platina; nor with compoſitions of ſulphur and fixed alcaline ſalts, as *liver of ſulphur*; which diſſolve gold itſelf. Hence zinc may be purified from the lead, of which it commonly has ſome admixture, by injecting ſulphur upon it in fuſion; for the lead is abſorbed by the ſulphur, and forms with it a concrete, which floats unmelted on the ſurface, and may be eaſily ſcummed off. *Lewis.*

ſtrongeſt attraction to gold and copper, and this laſt metal acquires a yellow colour by it; which has occaſioned many experiments to be made to produce new metallic compoſitions [e].

f. It is diſſolved by all the acids: of theſe the vitriolic acid has the ſtrongeſt attraction to it; yet it does not diſſolve it, if it be not previouſly diluted with much water. The abundance of phlogiſton in this ſemi-metal is perhaps the reaſon of its ſtrong attraction to the vitriolic acid.

g. Quickſilver amalgamates more eaſily with zinc than with copper, by which means it is ſeparated from compoſitions made with copper.

h. It ſeems to become electrical by friction, and then its ſmaller particles are attracted by the loadſtone; which effects are not yet perfectly inveſtigated; but they may excite philoſophers to make farther experiments, in order to diſcover whether the electrical power ſhews itſelf in the metals, by being attracted by the loadſtone, or whether the magnetic power can be exerted on other metals than iron [f].

SECT.

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[e] The proceſs for giving the yellow colour to copper, by the mixture of zinc, and of its ore called *Calamine*, has been deſcribed in Sect. 332. pag. 707. See alſo Nº 3. of the note to p. 672. *The Editor.*

[f] It has been ſaid, already, in the note to p. 756. that no other metal beſides iron, or in which ſome iron particles are contained, has any true attraction to the loadſtone.

SECT. 357. (Additional.)

Native Zinc.

Zinc has been found native, though rarely, in the form of thin and flexible filaments, of a grey colour, which were eaſily inflamed, when applied to a fire.

Bomare aſſerts to have ſeen many ſmall pieces of native zinc among the calamine-mines in the Duchy of Limbourg, and in the zinc-mines at Goſlar, where this ſemi-metal was always ſurrounded by a kind of ferrugineous yellow earth, or ochraceous ſubſtances; and adds, that he did not know any author who had mentioned the exiſtence of this native zinc at Goſlar.

Various mineralogiſts have entertained, indeed, their doubts, about native zinc; but this being a ſimple negative argument, cannot invalidate the poſitive aſſertion of ſuch an eye-witneſs as Bomare. Beſides, our own Author ſpeaks very poſitively in the following Sect. 361. of zinc in a *metallic form*, mineraliſed by ſulphur; and there is not the leaſt contradiction, in admitting that it may be equally found alone without any mineralizer.

The Editor.

ſtone. Even pieces of brass and other metals, which ſhew not the leaſt attraction to the magnet, if they are hammered, or pounded in an iron mortar, or with an iron-peſtle, or hammer, are found often to have acquired a magnetical power, although there be not the leaſt viſible particles of the iron attached to them. *See however* Sect. 389. *and fol. The Editor.*

SECT. 358. (228.)

Zinc in a calciform ſtate.

Zinc is found,

A. In form of calx, *Zincum calciforme naturale.*

1. Pure, *Minera zinci calciformis pura.*

a. Indurated, *Indurata.*

1. Solid.

2. Cryſtalliſed.

This is of a whitiſh grey colour, and its external appearance is like that of a lead ſpar; it cannot be deſcribed, but is eaſily known by an experienced eye. It looks very like an artificial glaſs of zinc, and is found among other calamines at Namur, and in England [*a*].

SECT.

[*a*] The pure zinc-ore, according to Bergman, is mineralized by the *aerial acid*; and is generally diſtinguiſhed by the name *vitreous*, on account of its ſimilarity to the artificial glaſs of zinc; as the Author remarks in the text, it is ſometimes hard enough to ſtrike fire with hard ſteel, becomes yellow when roaſted, effervesces, and diſſolves almoſt intirely with acids, particularly the vitriolic and marine. Brunnich ſays, that this ore is ſometimes found in the form of *ſtalactites*.

The Engliſh mines at Mendip hills contain a good deal of calamine; among ſeveral varieties, I got one in polyhedral cryſtals, as a very ſcarce one. The miners call it *Bony Calamine*. *J. R. Forſter.*

The

SECT. 359. (Part of 228.)
Calamine.

2. Mixed, *Minera zinci calciformis impura.*
a. With a martial ochre, *Ochra ſive calx zinci martialis.*
1. Half indurated, *Ochra zinci indurata.*
Calamine, *Lapis calaminaris* [*a*].
Whitiſh

The zinc ſpar is of a whitiſh, grey, bluiſh-grey, or yellowiſh colour, and of a hardneſs generally ſufficient to ſtrike fire with ſteel.

In its fracture it reſembles *quartz*. It is amorphous, ſtalactitical, or cryſtallized in groups, and weighty.

By calcination it loſes $\frac{1}{3}$ of its weight, without emiting any ſulphureous or arſenical ſmell.

Is infuſible in the ſtrongeſt heat, either ſingly or with mineral alkali; but is fuſible either with borax or microcoſmic ſalt.

In the mineral acids it is ſoluble with effervescence: and, with the vitriolic, affords vitriol of zinc.

100 gr. of this ore contains about 65 of the calx of zinc, 28 of aerial acid, 6 of water, one of iron, and ſometimes a little ſilex. *The Editor, from* Kirwan, p. 313.

[*a*] Calamine is of various colours, *viz*, white, grey, yellow, brown, or red. It is not ſo brittle as the tutenago-ore; but is of various degrees of hardneſs, though ſcarcely ſo hard as to ſtrike fire with ſteel.

Its ſtructure is either equable or cellular; and its form is either amorphous, or cryſtallized, or ſtalactitical.

When calcined it loſes no part of its weight, except it be mixed with charcoal, and then flowers of zinc ſublime.

It is ſoluble in acids; and, with the *vitriolic*, affords *vitriol of iron* as well as of zinc; which ſhews that the iron it contains is not much dephlogiſticated.

a. Whitiſh yellow, from Tarnovitz in Sileſia, England, and Aix-la-Chapelle.

b. Reddiſh brown, from Poland and Namur.

This ſeems to be a mouldered or weathered blende.

2. *b.* With a martial clay or bole, from Hollberget in Norberke, in Weſtmanland. Sect. 135. (86.) *d.*

c. With a lead ore and iron, England.

The ſpecific gravity of the beſt ſort, that is the grey, is =5,000. 100 parts of this afforded to Bergman 84 of *calx of zinc*, 3 of *iron*, 1 of *argill*, and 12 of *ſilex*. But in other ſpecimens, theſe proportions are very different. A good ore ſhould afford at leaſt 30 *per cent*; and its ſpecific gravity ſhould be about 4,400, or 5,000.

Some of theſe ores are not ſo poor as not to contain above 4 *per cent.* of calx of zinc.

Calamines contain ſometimes a mixture of calcareous earth and lead. Moſt of the Engliſh calamines contain lead. Kirwan, p. 315.

The *Tutenago-ore*, brought from China, and analyſed by Engeſtrom, is an ore of zinc, in which a notable proportion of iron is contained. It was of a white colour, interſperſed with red ſtreaks of calx of iron, and ſo brittle as to be eaſily broken betwixt the fingers. It did not loſe weight by being roaſted; was ſoluble in the mineral acids, particularly with the aſſiſtance of heat; and, with the vitriolic, afforded vitriol both of zinc and of iron. The quantity of fixed air was ſo ſmall as to be abſorbed by the ſolution. It contained from 60 to 90 *per cent.* of zinc: the remainder was iron, and a ſmall proportion of argill. Biddheim diſcovered alſo this variety of zinc-ore in Germany; which contained alſo a little *iron* and ſome *ſilex*. *The Editor from* Kirwan, p. 314.

SECT.

SECT. 360. (Additional.)

Zeolytiform Zinc-ore.

The real contents of this ſubſtance were firſt diſcovered by Pelletier, a moſt accurate Pariſian chymiſt.

It was long taken for a zeolite, being of a pearl-colour, cryſtalliſed, and ſemi-tranſparent.

It conſiſted of laminæ, diverging from different centers:

And becoming gelatinous with acids.

It was commonly called *Zeolyte of Friburgh.*

And contains 48 to 52 *per cent.* of quartz, 36 of calx of zinc, and 8 or 12 of water. Ed. from Kirwan, p. 318.

SECT. 361. (229.)

Zincum Mineraliſatum.

B. Mineraliſed zink,

1. With ſulphurated iron, *Zincum ferro ſulphurato mineraliſatum.* Blende, Mock-lead, Black jack, Mock ore: the *Pſeudo-galena* and *Blende* of the Germans [*a*].

Mineraliſed

[*a*] According to Mongez, the pſeudo galena is ſometimes ſemi-tranſparent, and cryſtalliſed; and almoſt always intermixed

a. Minetaliſed zinc in a metallic form, *Zincum formâ metallicâ ſulphuratum.* Zink ore.

This is of a metallic blueiſh grey colour, neither perfectly clear as a potter's ore, nor ſo dark as the Swediſh iron ores [*b*].

1. Of a fine cubical or ſcaly texture, from China, Kongſberg, and Jarlſberg in Norway.
2. Steel-grained, from Bowallen and Skienſhyttan, in the pariſh of Tuna, in Dalarne.

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intermixed with *ſilver*, *lead*, *copper*, *arſenic*, and other metals, as well as with argillaceous and calcareous earth. But, as Bergman obſerves, the *zinc*, *iron*, and *ſulphur*, are the only neceſſary ingredients for the formation of this ore.

[*b*] The principal varieties of *blende*, or *pſeudo-galena*, are,

1. The ſcaly form, and that compoſed of ſmall cubes, ſimilar to the *galena*. It is of a dark grey colour, and ſometimes ſtrikes fire with hard ſteel.

2. The ſcaly greeniſh-black coloured ore, reſembling pitch, called *Pechblende* by the Germans. See the following Section.

3. The *red* coloured, which produces a reddiſh powder when ſcraped with a knife, and turns yellowiſh by calcination.

4. The phoſphoric, or ſparkling blend, to be mentioned in Note to Sect. 362. which is of a yellowiſh colour, or opake, or ſemi-tranſparent; and, on being rubbed with a pen, in a dark place, it produces luminous ſparks of a yellowiſh light. From Mongez.

5. And the *red*, phoſphoreſcent when rubbed, which is found at Scharfenberg in Miſnia, as Brunnich aſſerts. *The Editor.*

In all probability this ore is the *glanz blende* of Sect. 363, where its full deſcription may be ſeen. *The Editor.*

SECT. 362. (230.)

Zinc Pſeudo-galena.

b. In form of calx, *Zincum calciforme cum ferro ſulphuratum.* Blende. Mockead, *Sterile nigrum. Pſeudogalena.* This is found, [*a*]
1. With coarſe ſcales,
a. Yellow, ſemi-tranſparent, from Scharffenberg in Miſnia, Schemnitz and Kongſberg [*b*].
b. Greeniſh, from Kongſberg.

Black,

[*a*] There are ſeveral varieties of *Pſeudo-galena*, or *Black Jack*. They are in general of a lamellar, or ſcaly texture, and frequently of a quadrangular form, reſembling *galena*. They all loſe much of their weight when heated, and burn with a blue flame; but their ſpecific gravity is conſiderably inferior to that of true *galena*. Almoſt all contain a mixture of lead-ore. Moſt of them exhale a ſulphureous ſmell, when ſcraped; or at leaſt when vitriolic or marine acid is dropped on them. *The Editor from* Kirwan, p. 319.

[*b*] This ore is as yellow as wax; is ſemi-tranſparent, and contains much ſulphur.

In the dry way zinc is reduced from this ore, by diſtilling it, after torrefaction, with a mixture of its own weight of charcoal, in an earthen retort well luted, in a ſtrong heat: but, by this method, ſcarce half of the zinc it contains is obtained. Kirwan, p. 323.

Another greyiſh yellow blende, is found alſo, that conſiſts of a mixture of blende, galena, and petrol.

It contains about 24 *per cent.* of zinc, and is probably the ſame as the grey blende mentioned by Monnet. Kirwan, p. 323.

This

c. Black, *Pechblende* or *Pitch Blende* of the Germans, from Salberg and Falun in Sweden, and from Saxony.

d. Blackiſh brown, from Storfallſberget in Tuna in Dalarne [*c*].

2. With fine ſcales [*d*],

a. White, from Silfberget in the pariſh of Rettwik in Dalarne.

b. Whitiſh yellow, from Rettwik.

Reddiſh

[*c*] This ore is of a black colour, and of a moderate hardneſs.

It does not give fire with ſteel.

Is frequently cryſtallized; and

Is then ſometimes tranſparent, or ſemi-pellucid:

When pulverized it affords a reddiſh powder.

If heated it decrepitates: emits a ſulphureous ſmell, if laid on burning coals: and depoſits white and yellow flowers.

It is not magnetic, even after torrefaction, but loſes 25 per cent of its weight.

It is frequently mixed with ſilver, arſenic, and other metals.

100 parts of this ore, from Danemora, being examined by Bergman, exhibited 45 of zinc; 1 of regulus of arſenic; 9 of iron; 6 of lead, all ſlightly dephlogiſticated; 29 of ſulphur; 6 of water; and 4 of ſilver. *Kirwan*, p. 321.

[*d*] The cryſtallized blendes deſerve to be mentioned in this place:

a. Dark red, very ſcarce; found in a mine near Freyberg. Something like it is found at the Morgenſtern and Himmelsfurſte.

b. Brown. In Hungary and Tranſilvania.

c. Black. Hungary.

Theſe laſt varieties may eaſily be miſtaken for tin-cryſtals; but, by experience, they may be diſtinguiſhed on account of their lamellated texture and greater ſoftneſs.

Their tranſparency ariſes from a very ſmall portion of iron in them. *Brunnich.*

The

c. Reddiſh brown, from Salberg, Silfverberget, and Hellefors in Weſtmanland [e].

3. Fine and ſparkling; at Goſlar called *Braun Bleyertz* [f].

Dark

[e] The texture of this ore is generally ſcaly: ſometimes cryſtallized and ſemi-tranſparent.

It gives fire with ſteel; but

Does not decrepitate, nor ſmoke when heated:

Yet it loſes about 13 *per cent.* of its weight by torrefaction.

One *hundred* parts of this ore, from Sahlberg, contained (by Bergman's analyſis) 44 of zinc, 5 of iron, 17 of ſulphur, 5 of water, 5 or argill, and 24 of quartz. *See the* proceſs for *analyſing this ore, in* Kirwan, p. 322.

[f] There is a red blende, which becomes phoſphoreſcent when rubbed. This is found at Scharfenberg in Miſnia. *Brunnich.*

Another *Phoſphoreſcent Blende* is generally greeniſh, yellowiſh-green, or red; and has different degrees of tranſparency; and is ſometimes quite opaque.

When ſcraped with a knife in the dark, it emits light, even in water; and after undergoing a white heat, if it is diſtilled *per ſe*, a ſiliceous ſublimate riſes, which ſhows it contains the *ſparry acid*, probably united to the metal, ſince it ſublimes.

This ore is almoſt wholly ſoluble in the marine acid with a boiling heat.

Bergman found 100 *gr.* of this ore from Scharfenberg, to contain 64 of zinc; 5 of iron; 20 of ſulphur: 4 of *fluor acid*; 6 of water; and 1 of ſilex. *Editor from* Kirwan, *p.* 323.

The zinc, in the laſt kind of blendes mentioned in this Section, is, as it were, in the form of a calx or glaſs, ſo that they are often tranſparent. On the contrary, in the zinc ore of Sect. 361. [a], it ſeems to be in a metallic form, or, like moſt other metals, mineraliſed with ſulphur.

The ſulphur, nevertheleſs, exiſts in the different kinds of blende, equally as in the zinc-ore: and this remarkable difference in their appearance muſt be accounted for from another principle than the quantity of zinc which they contain;

a. Dark Brown, from Rammelſberg in the Hartz, and Salberg in Weſtmanland.

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tain; becauſe the yellow and the white blendes are often found to be richer than the zinc-ores; but theſe laſt are, however, more profitably worked for the metal. Perhaps it is becauſe the blend does not contain a ſufficient quantity of the phlogiſton of the ſulphur, to prevent the calcination of the zinc.

It is no matter whether a calcined blende is called *calamine* or not, provided it has ſuch properties, that it may be employed to the ſame purpoſes, and with the ſame effect as that calamine, which nature has freed from its ſulphur, by its withering or decaying. This may be done with ſome kinds of blende; and Mr. Von Swab has given evident and excellent proofs of it in Sweden; in ſo much that it would demonſtrate a want of experience to inſiſt that ſulphur cannot be expelled by calcination, without deſtroying the zinc itſelf; and that flowers of zinc may be produced from zinc ores in a calcining heat, without addition of any phlogiſton.

Mr. Juſti, however avers, that he has found an ore of this quality, which in his Mineralogy he calls *Zinc-ſpat*; but there is great reaſon to doubt whether it really contains any zinc, until it is ſhewn whether the author added any phlogiſton during the calcination, or reduced the zinc out of it; becauſe, although the flowers of zinc may not always be perfectly well calcined, yet there is no inſtance of a natural zinc-ore being diſcovered, which by itſelf yields thoſe flowers during calcination. And it requires, beſides, a ſtrong heat to produce theſe flowers from a perfect calx or glaſs of this ſemi-metal, either natural or artificial, though mixed with a phlogiſton: for it could not have been a native zinc, ſince it reſembled a ſpar, and ſuch a one very likely is not to be found in nature. *The Author.*

SECT.

SECT. 363. (Additional.)

Glanz blende [*a*].

This ore has a metallic appearance.
Is of a bluiſh grey.
Its form is generally cubical or rhomboidal.
Is of a ſcaly or ſteel-grained texture.
It loſes nearly one ſixth of its weight by calcination; and after calcination it is more ſoluble in the mineral acids.

One hundred parts of this ore afforded to Bergman about 52 of *zinc*; 8 of iron; 4 of copper; 26 of ſulphur; 6 of ſilex; and 4 of water. *Kirwan.*

[*a*] To analyſe this ore in the *moiſt way*; Bergman firſt expelled the water and part of the ſulphur by diſtillation. The reſiduum he treated with 3 times its weight of oil of vitriol, carrying the evaporation to dryneſs; this he lixiviated with warm water, and found only 6 parts undiſſolved. In this ſolution a poliſhed plate of iron was boiled, which precipitated the copper. He then, by means of the phlogiſticated alkali, precipitated the *zinc* and *iron*. The precipitate being calcined in an open fire, was ſeveral times treated with nitrous acid, and evaporated to dryneſs, until the iron was perfectly dephlogiſticated; freſh nitrous acid being then added, diſſolved the zinc only, which being precipitated by the Pruſſian alkali, the proportion of zinc was found in its metallic ſtate.

Neither metal contained in this ore is much dephlogiſticated. *See the* proceſs *properly deſcribed by Kirwan, at p.* 317 *and following.* The Editor.

SECT.

SECT. 364. (122-3)

Zinc mineralised by the vitriolic acid.

This ore has been already described in Sect. 210. and in the notes p. 411.

SECT. 365. (231.)

Observations on Zinc [a].

It appears from old coins, and other antiquities, that the making of brass was known in

[a] 1. Zinc is also called by Neumann and various other authors by the names of *Tutenago*, *Spiauter*, *Contrefait*, and *Spelter*. The Dutch bring to Europe, in the *East India* ships, a great quantity of *tutenago*, which is a little *bluer* than the German zinc, and also more tenacious. But we know nothing certain (says Cramer), either of the country where the ore that contains this zinc is found, and much less of the manner in which this semi-metal is obtained from it: for it is asserted that no European is granted the liberty of entering into the Chinese manufactories.

2. We have obtained, however, since the time of Cramer, some knowledge respecting the contents in the Chinese *tutenago* ore, as appears by the last note to Sect. 359. pag. 776.

3. As to the German zinc, it is well known, that it is not extracted from any ore by eliquation, as other metals and semi-metals are melted out from theirs; and in fact all the zinc that is there prepared is obtained by sublimation, not from

in the moſt antient times; and that it was their *Æs Corinthiacum*, which contained copper and zinc. But it is not long ſince this ſemi-metal was diſcovered to lie concealed in calamine, and that calamine was its peculiar ore, and alſo a body of diſtinct qualities, prepared by nature, equal to that which is got tolerably pure at the furnaces of Goſlar, or that is imported from China, under the name of *tutenago*.

Mr.

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from any ſingular ore, but out of an intricate and confuſed mixture of different ores, ſome of which contain zinc; at the ſame time that ſeveral other metals, and ſemi-metals, are ſeparated from the ſame; ſuch as *iron*, *lead*, and *copper*, which are almoſt all combined with *ſulphur*, and *arſenic*.

3. And moreover no peculiar ſublimation is there employed for the extraction of that zinc, it being only by a ſecondary operation, that the volatile fumes of zinc are collected at the ſame time, during the eliquation of the other metals, eſpecially of lead. It may be eaſily conceived by the deſcription given by Cramer of the ſmelting furnaces of Goſlar, that it muſt have been merely chance without deſign that the upper channel was applied within them, by which a very ſmall part of the volatilized zinc, is preſerved and reduced into its reguline form; ſo that out of the vaſt quantity of ores ſmelted there which, within the ſpace of 18 hours, is more than 60,000 weight, hardly 3, or at moſt 5, pounds of zinc are obtained.

4. Pott, on his *Eſſay on Zinc*, ſays, that our countryman, Dr. Iſaac Lawſon, of whoſe great knowledge in mineral chemiſtry he ſpeaks very reſpectfully, really obtained ſome ſmall quantity of regulus of *zinc* from *calamine*; and makes ſeveral quotations from a Diſſertation publiſhed by the ſame Dr. Lawſon, upon the *nihil*, or *flowers of zinc*. Dr. Campbell likewiſe aſſerts poſitively, in his *Survey of Great Britain*, that Dr. Lawſon diſcovered *calamine* to be the true mine of this ſemi-metal. In all probability this was the ſame learned gentleman, by whom Cramer had been employed in Eng-

Mr. Brandt removed a great many doubts about the origin of zinc, and the metallic earth of the calamine, by having in the year 1734, a favourable opportunity of examining the calamines, and different kinds of blends, from Rettwik in Dalarne. He then proved, in his *History of the Semi-metals*, that blends and calamines are ores of zinc; and that the *Galitzenstein* (Sect. 210 of this Edit.) of the Germans was its vitriol.

Soon

land, as his Operator in chemistry. He resided a long time afterwards at Leyden, living in great intimacy with *Boerhaave*, *Vanswieten*, *Gaubius*, *Grenovius*, and with several other men of great learning in that flourishing university, and went at last to Flanders, where he died in the year 1745. It is to his care and trouble of reducing into order, and writing for the press, the *course of lectures* and *experiments*, given at Leyden in 1735, to a society of gentlemen, most distinguished for their skill in all branches of natural philosophy, that the world is indebted for that excellent work, intitled *Elements of Essaying Minerals*, by *J. A. Cramer*. This last gentleman did collect, indeed, the chief part of the materials; but they would probably have remained buried in oblivion, without the assiduous labour and industrious care and intelligence of Dr. Lawson, as may be seen by the advertisement prefixed by Dr. C. Mortimer to the second edition of that work.

5. It deserves notice, however, that, although Dr. Lawson was acquainted with the method of smelting zinc from calamine, he never gave the least hint of the process in the said work of Cramer. Perhaps he was in hopes of publishing it afterwards at large, in a compleat work on the subject, from which performance he was unhappily prevented by his untimely death. It is proved, beyond all controversy, by the arguments and authorities adduced by Dr. Watson, in the second Essay of his fourth volume, that the ancients, and particularly the Romans, formed their *orichalcum*, as we do our *brass*, by melting copper with calamine, &c. This

4 operation

Soon after, the bluiſh-grey zinc-ore was diſcovered by Mr. Von Swab at Bowallen, who, in the year 1738, prepared calamine from it, and erected a work for diſtilling zinc at large from it, at Weſterwiken in Dalarne; which manufacture, however, afterwards was laid aſide for other intervening buſineſs.

Thus theſe firſt diſcoverers might perhaps have given to Meſſieurs Pot and Margraff, the opportunity

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operation has been fully deſcribed in the note [g] to Sect. 332. p. 707. But it was reſerved for modern metallurgiſts to diſcover, that this phenomenon is produced by a volatile ſubſtance, which can aſſume a ſolid ſtate or form, like any other ſemi-metal.

6. The two principal ores of zinc are now very well known to be *calamine* and *blende*. The name of the firſt is taken from the Arabic *climia* or *calamia*, which denotes, as Watſon aſſerts, the very ſame ſemi-metal; but, by the word *blende*, the Germans mean a *miſleading* or *blinding* mineral; becauſe, notwithſtanding the great reſemblance of *blende* to the *lead-ore*, on account of its ſhining particles, nevertheleſs it does not yield any lead at all. From thence blende is alſo called the *Pſeudogalena*, and *Mock-lead*; and in fact many unexperienced ſmelters have been deceived by this great ſimillarity, buying *blende* for the true *galena*, which is called *Potter's lead ore* of Derbyſhire. But in general *blende* is better known among our Engliſh miners by the nick name of *black-jack*; by whom it is diſpoſed of to the makers of braſs.

7. Calamine is found in many parts of Europe; and we have great plenty of it in *Somerſetſhire*, *Flintſhire*, *Derbyſhire*, and in many other parts of England. It is ſcarcely to be diſtinguiſhed by its appearance from ſome ſorts of *lime-ſtone*; for it has none of the metallic luſtre uſually appertaining to ores, and only differs by its ſpecific gravity, it being near twice as heavy as *flint* or *lime-ſtone*.

8. The firſt dreſſing of the calamine conſiſts in picking out all the pieces of *lead-ore*, *lime*, and *iron-ſtone*, *cauk*, and

opportunity to make the hiſtory of zinc more known to the world: the former in his *Treatiſe de Pſeudogalena* in the year 1741; and the latter, in the *Memoirs* of the Academy of Berlin: though this notice is by no means intended to deprive theſe ingenious gentlemen of the honour they merit, for having had of themſelves the ſame opinion, and propoſing the ſame experiments.

The

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other heterogeneous ſubſtances, which are found mixed with it in the mine: it is then calcined in proper furnaces, where it loſes about a fourth or third part of its weight. It is picked out again very carefully, as the heterogeneous particles have become more diſcernible, by the action of the fire; it is then ground to a fine powder, and waſhed in a gentle rill of water, which carries off the earthy mixtures of extraneous matters; ſo that, by theſe proceſſes, a *ton* weight of the crude calamine of Derbyſhire is reduced to *twelve hundred* only.

9. As to the *blendes* or *black-jack*, they vary very much in their external appearances and internal conſtitutions, as was deſcribed in the preceding ſections. In general, the blendes contain *zinc* and *ſulphur* united together by the intervention of *iron*, or of *calcareous earth*; and muſt be previouſly freed of the *ſulphur* by means of calcination, to produce zinc.

Bergman aſſerts that a certain Engliſhman made, ſeveral years ago, a voyage to China, for the purpoſe of learning the art of ſmelting zinc, or tutenago; but though he became inſtructed in the ſecret, and returned ſafely home, he carefully concealed it.

10. The manufactory of zinc was, however, eſtabliſhed in England about the year 1743, when Mr. Champion obtained a patent for the making of it, and built the firſt work of the kind near Briſtol. It conſiſts, as Watſon relates, of a circular kind of oven, like a glaſs-houſe furnace, in which were placed 6 pots, of about 4 feet each in height, much reſembling large oil-jars in ſhape, into the bottom of each

The zinc from Ramelſberg in the Hartz, is like moſt of the lead and copper ores from the ſame mines of a very fine grained texture, which we call *Steel-compact*; and is likewiſe ſo often equally mixed with the ſaid copper and lead ores, as not to be ſo eaſily perceived, if one is not previouſly acquainted with them. It ſeems, nevertheleſs, reaſonable that a true mineraliſt ought rather to ſuſpect the ore called

Brown

each pot is inſerted an iron tube, which paſſes through the door of the furnace, into a veſſel of water. A mixture of the prepared ore, as mentioned above N° 8 and 9, is made with charcoal, and the pots are filled with it to the mouth, which are then cloſe ſtopped with ſtrong covers, and luted with clay. The fire being properly applied, the metallic vapour of the calamine iſſues downwards, or *per deſcenſum*, through the iron tubes, there being no other place through which it can eſcape; and the air being excluded, it does not take fire, but is condenſed in the water into granulated particles; which being remelted, are caſt into ingots, and ſent to Birmingham under the name of *zinc* or *ſpelter*; although by this laſt name of *ſpelter*, only a granulated kind of ſoft braſs is underſtood among the braſiers, and others who work in London, uſed to ſolder pieces of braſs together.

11. Great part of the zinc volatilized, by the force of fire in large furnaces, as thoſe at Goſlar, adheres to their ſides in the form of a whitiſh calx; this is ſcraped off, when the furnace is cold, and is called by the name of *Ofenbruch*, or *Cadmia fornacum*, which is employed, as well as zinc, to make braſs.

12. Another ſubſtance, common in the ſhops, is called *Tutia*, or *Tuthia*, according to Lemery. This ſeems to be ſome preparation of the calx of zinc with other matters, and varies very much in its contents, as well as external appearances: it changes, or ought to change, copper alſo into braſs; and is employed in the compoſition of ſome unguents by the apothecaries, although the effects muſt vary, according to the integrant parts of this compound.

Brown Bleyerts (Sect 362-3) to be a zinc-ore, than to ſuppoſe this ſemi-metal to be a product of *lead*, *copper*, and *iron*.

SECT. 366. (232.)

4. Antimony. *Antimonium. Stibium.*

Its general properties [*a*].

This ſemi-metal is,

a. Of a white colour almoſt like ſilver.

Brittle:

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13. The *Pompholix*, *Diphryges*, *Nihil*, *Nihil album*, *Spodium Græcorum*, *Cadmia botrites*, *Zonites*, *Onychites*, *Oſtracites*, *Placites*, *Capnites*, &c. mentioned by medicinal and metallurgical writers, are productions of zinc, with various external appearances of colour, and conſiſtence or form, which differ very little, or perhaps nothing at all, from themſelves in their properties; but are cheriſhed by whimſical authors on account of the ſingularity of their names. *The Editor* from *Neumann*, *Watſon*, &c.

[*a*] The colour of antimony, in its reguline form, is of a ſilver white; its texture appears micaceous; and is remarkably brittle.

Its ſpecific gravity, when perfectly freed from iron, is = 6,860.

The *nitrous acid* dephlogiſticates antimony; but holds only a very minute portion of it in ſolution.

The *vitriolic acid*, if boiling, diſſolves antimony; but the *muriatic* and *acetous* acids act hardly at all upon it, unleſs previouſly calcined.

Aqua regia formed of 7 parts of *marine* and one of *nitrous* acid, diſſolves this ſemi-metal in a conſiderable degree.

It is alſo ſoluble in a mixture of the *vitriolic* and *marine* acids, or even of the *vitriolic* and *nitrous* acids.

The

b. Brittle; and in its texture, it conſiſts of ſhining planes, of greater length than breadth.

c. In the fire it is volatile, and volatiliſes part of the other metals along with it, except gold and platina. It may, however, in a moderate fire, be calcined into a light grey calx, which is pretty refractory in the fire, but melts at laſt to a glaſs of a reddiſh brown colour.

d. It diſſolves in ſpirit of ſea-ſalt and *aqua regia*, but is only corroded by the ſpirit of nitre into a white calx; it is precipitated out of the *aqua regia* by water.

It

The phlogiſton it loſes by ſolution, is expreſſed by 120; and in reſpect to the force wherewith it retains this, it ſtands in the *ſixth* place.

It melts in the fire long after it becomes *red hot*, *viz.* at the 809 *degree*; provided it be in its pure reguline form; otherwiſe it melts at the flame of a candle. When melted, it emits a white ſmoke, and evaporates, forming itſelf into white and refractory flowers, as the author remarks. *See the* N° 10 *of the note to Sect.* 372.

In cloſe veſſels it ſublimes without decompoſition. *Bergman*, *Kirwan*, &c.

Crude antimony ſoils the fingers, when handled.

It is found in different parts of Europe, as Bohemia, Saxony, Tranſylvania, Hungary, Sweden, Spain and France, &c. it commonly lies alone in mines, intermixed with earthy or ſtony matters.

Sometimes it is blended with the richer ores of ſilver, and renders the extraction of that metal very difficult; for the antimony volatilizes a part of the ſilver, or *robs the ore*, as the miners expreſs themſelves.

It is ſeparated from its natural impurities by fuſion, in an earthen pot, whoſe bottom is perforated with a number of

e. It has an emetic quality when its calx, glaſs, or metal, is diſſolved in an acid, except when in the ſpirit of nitre, which deprives it of this effect.

f. It amalgamates with quickſilver, if the regulus when fuſed, be added to it; but the quickſilver ought for this purpoſe to be covered with warm water: it amalgamates with it likewiſe, if the regulus of antimony be previouſly melted with an addition of lime.

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holes; it is then ſurrounded by burning coals: the fluid antimony paſſes through the holes, whilſt the unfuſible matters remain behind. This melting veſſel muſt have been let into the mouth of another pot, ſunk in the ground, which ſerves as a receiver, in this kind of melting *per deſcenſum*. The juncture of the two veſſels muſt be cloſely luted; and ſeveral ſets of this apparatus are generally worked at once. *See the laſt* N° *of the note to Sect.* 369.

In the purification of gold, when it contains other metals, antimony is employed. *See* the N° 8 of the note to Sect. 372.

The *flowers of antimony*, already mentioned, are nothing elſe but its pure calx; and, if put in a proper degree of fire, in a cloſe crucible, produce a browniſh red glaſs of a deep hyacinthine colour. See N° 12 of the Note to Sect. 372.

If antimony is melted in a cloſe crucible, and is cooled gradually, it aſſumes the form of inſulated pyramids, and ſometimes of a regular form of ſtars.

This ſemi-metal combines very well with ſulphur.

Crude antimony being projected in a crucible, in which an equal quantity of nitre is fuſed, detonates; is calcined, and forms a compound, called by the French, *Fondant de Rotrou*, or *Antimoine Diaphoretique non lavé*. This being diſſolved in hot water, falls to the bottom after it is cold; and after decantation, is known, when dry, by the name of *Diaphoretic Antimony*. *Mongez*. See the note to Sect. 372, N° 20.

SECT.

SECT. 367. (233.)

Native Antimony.

Antimony is found in the earth.

A. Native, *Antimonium nativum, ſive, Regulus Antimonii nativus.*

This is of a ſilver colour, and its texture is compoſed of pretty large ſhining planes.

This kind was found in Carls Ort, in the mine of Salberg, about the end of the laſt century [*b*], and ſpecimens thereof have been preſerved

[*b*] Since native antimony, or, as it is commonly called, *regulus of antimony*, was never before known, the poſſibility of its exiſtence has been denied; and when the ſpecimen here mentioned, was diſcovered, a certain perſon publiſhed his doubts of the truth of the whole affair, upon no better foundation than that the ſpecimens were very ſmall for making experiments, and that it was uncertain if ever mineraliſed antimony had been found in the mine of Salberg.

But thoſe reaſons are not ſufficient to refute experiments, becauſe men of experience are always able to make true experiments on ſmall pieces of native metal; nor is there any neceſſity that mineraliſed metals ſhould always be found along with the native ores of the ſame ſpecies; though this really happens with this antimony in the mine at Salberg.

We ought to be contented with concluſions drawn from experiments, until the fallaciouſneſs of ſuch experiments is demonſtrated. And it were to be wiſhed, that all pretended diſcoveries were ſupported by experiments, and an enumeration of the phenomena which happen in them; we ſhould then not contradict things, which perhaps may be true, though, for want of this precaution, they ſeem ſcarce credible; as, for inſtance, the *native tin*, *lead*, and *iron*, the

preſerved in collections under the name of an arſenical pyrites, till the mine-maſter Mr. Von Swab diſcovered its real nature, in a treatiſe he communicated to the Royal Academy of Sciences at Stockholm, in the year 1748. Among other remarkable obſervations in this treatiſe, it is ſaid, *firſt*, That this native antimony eaſily amalgamated with quickſilver; doubtleſs, becauſe it was imbeded in a limeſtone; ſince, according to Mr. Pott's experiments, an artificial regulus of antimony may, by means of lime, be diſpoſed to an amalgamation. 2. *Secondly*, that it yielded criſtals *in forma calcis*, during the cooling.

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the *zink ſpar*, and an unknown ſemi-metal in the mica. *The Author.*

Counſellor Muller, in a letter of the 21ſt September 1782, inſerted in *Journ. de Phyſique*, for July 1787, and directed to Baron de Born, pretends that the above ore of *native antimony*, acknowledged as ſuch by Mr. Von Swab, was nothing but a true native biſmuth. Mr. de Reprecht, however, wrote, on the 20th of October following, a full refutation of C. Muller's arguments, to the ſame Mr. de Born. This laſt letter was alſo inſerted in the next article of the ſame *Journal de Phyſique*; and ſhews the power of old prejudices, in ſpite even of ocular demonſtrations.

But Mr. de Reprecht, it ſeems, has recanted, *honourably*, if influenced only by the love of truth! *See pag. 231. of the ſame* Journal *for September following.*

It appears by the ſame letters, that *native antimony* is found alſo in different other ores, as thoſe from *Fozebay* and Tranſylvania; and that the *blackgold-ores* from *Nagyag*, contain not only *gold*, but alſo *ſilver*, *iron*, *lead*, *antimony*, *arſenic*, and *ſulphur*, whoſe reſpective proportions, Mr. de Ruprecht, had undertaken to aſcertain.

And laſtly, Mr. Mongez above quoted, has given a full account of the *native antimony* found in the mines of Allemond in Dauphiny by Mr. Schreiber, ſome ſamples of of which he examined by the *dry* and *humid way*, which he found to be alloyed with about 3 *per cent.* of arſenic. See the Journal de Phyſique *for July* 1783, *p.* 66. The Editor.

SECT.

SECT. 368. (Additional.)

Antimony Mineralized by the Aerial Acid.

This ore was lately discovered by Mongez, among those of *native antimony*, from the mine of *Chalanges* in *Dauphiny*.

It consists of a group of white crystalized filaments of a needle-form appearance, diverging from a common center, like zeolyte.

They are insoluble in nitrous acid; and,

On being urged by the flame of a blow-pipe, upon a piece of charcoal, they are dissipated into white fumes, or antimonial flowers, without any smell of arsenic; from whence it follows, that these needle-formed crystals are a pure *calx of Antimony*, formed by its combination with, or mineralized by, the aerial acid. *See* Kirwan, *p.* 325, *and* Journal de Physique *for July* 1787, *p.* 67.

SECT. 369. (243.)

B. *Mineralized Antimony.*

1. With sulphur, *Antimonium sulphure mineralisatum. Antimonium proprie sic dictum* [c].

This is commonly of a radiated texture, composed of long wedge-like flakes or plates; it

[c] The mountains in Upper Hungary are all rich in these kinds of ore, especially in the county of *Liptaw*, whence it is exported to Poland. *Brunnich.*

The

it is nearly of a lead colour, and rough to the touch.

a. Of coarſe fibres.

b. Of ſmall fibres.

c. Steel-grained, from Saxony and Hungary.

d. Criſtalliſed, from Hungary.

1. Of a priſmical, or of a pointed pyramidal figure, in which laſt circumſtance the poinss run to one center.

I have ſeen a ſpecimen of this, in which the cryſtals were covered with very minute cryſtals of quartz, except at the extremities, where there was always a little hole. This ſpecimen was given for a *flos ferri* ſpar.

The ſulphureous ores of antimony are the moſt common, and the moſt productive of this ſemi metal.

The common *black-grey*, or *blueiſh antimony*, is moſt uſually of a ſtriated texture; yet there is ſome found without any determinate form, and in this caſe it may be eaſily miſtaken for the *ſmall-grained lead-ore*, or *white ſilver-ore*, or *iron-glimmer*; but the way to diſtinguiſh it immediately from theſe, is to hold only a piece of this ore in the burning flame of a candle; becauſe the antimony will melt in that low heat, which none of the other ores does; an experienced eye may readily diſcover it by the colour.

Crude antimony is not only that which is ſeparated and picked out in compact pieces from the ſtony or other heterogeneous matters of the ore; but alſo what is melted at firſt out of its mineral ſtones and earths, by fire. This ore has indeed its own regular veins like other minerals; and yet ſome other kinds of ores are ſometimes found along with it. *Gellert's Metallurgy, p.* 59.

The texture of theſe ores is not only *fibrous*, and often *inclined* to a common centre, but alſo *cuneiform*, *ſtriated*, *ſolid*, and lamellated: theſe laſt are ſometimes called *Antimo-*

nial

nial Galenas. They are alſo found ſometimes in a *plumoſe form*, conſiſting of extremely delicate fibres, like feathers.

As to colour, they are not only *dark* or blueiſh-grey, but ſometimes they ſhow, in their needle-form maſſes, the fineſt *purple*, variegated with ſhades of *red*, *blue*, *green*, *yellow*, and *whitiſh-grey*, like the pigeon's neck.

Wallerius and Bomare deſcribe other varieties of theſe antimonial ores, which differ by colour or ſhape; but it will be ſufficient to indicate only their deſcriptive Latin epithets, *viz.*

Striatum colore griſeo.
Fibroſum plumbo-ſimile.
Fibris parallelis.
Striis inordinatis.
Striis decuſſantibus.
Striis intercuſſantibus.
Striis ex centro divergentibus.
Striis concentricis.
Striis ſtellatis.
Striis in plana nitida concretis.
Striato-ſquamoſum.
Lanæ inſtar, fibris capillaribus ſeparatis.

Plumoſum, { *album.* *rubrum.* *flaveſcens.* *viride.* *cæruleſcens.*

Textura Chalybea.

Criſtalliſatum. { *figura incerta* *fig. turrita ceu pyramidalis.* *tuberoſa.* *nodoſa.* *druſica.*

Griſeum ſpeculare, cinereum, &c.

The ſpecific gravity of antimony is for the moſt part from 4 to 4200; and, when melted, from 4700 to 500. But if the regulus be well depurated from ſulphur and iron, its ſpecific gravity is much greater, as was mentioned in the note [*a*] to Sect. 366.

This ore of antimony ſoils the fingers when handled, and is very brittle.

When

SECT. 370. (235.)

Red-Antimony Ore.

2. With ſulphur and arſenic, *Antimonium auripigmento mineraliſatum.* Red antimony ore, *Antimonium ſolare.*

This is of a red colour, and has the ſame texture with the preceding, though its fibres are not ſo coarſe.

a. With ſmall fibres.

b. With abrupt broken fibres, from Braunſdorff in Saxony, and from Hungary [*d*].

All

When gradually heated in a crucible, it loſes about 22 *per cent.* of its weight; and becomes a grey calx.

It is perfectly ſoluble in the *marine acid*, with the aſſiſtance of heat.

The *nitrous* only calcines the reguline part.

100 parts of this ore contain 74 of the *antimonial regulus*, ſlightly dephlogiſticated, and 26 of *ſulphur*.

It is analyſed by ſolution in *aqua regia*, conſiſting of 1 part of *nitrous*, and 4 parts of *marine acid*. The ſulphur is found in the filter; for this ſolvent only acts on the ſemimetal, and the ſulphur being diſengaged, floats over the ſolution.

In the *dry way* antimony is ſeparated from the ſtony parts of its ore by diſtillation *per deſcenſum*. It is afterwards reduced to a regulus by gently roaſting it, until it loſes 22,5 *per. cent.* of its weight; and then mixing the grey calx thus formed, with twice its weight of *black flux*, and briſkly fuſing it in a covered crucible, the regulus is obtained. *The Editor from* Kirwan p. 326, and Mongez, *&c.*

[*d*] In Hungary nobody knows this kind of ore. I only found it at Braunſdorff: therefore ſome, who have not ſeen it, deny its exiſtence. *Brunnich.*

All antimonial ores are ſomewhat arſenical, but this is more ſo than the preceding kinds.

SECT. 371. (236.)

Mineralized with other metals.

C. With ſulphurated ſilver. The *plumoſe ſilver ore* of Sect. 274 [*e*].

With

The red-colour of this ore proceeds from the mixture of arſenic. Wallerius ſpeaks of 3 varieties of this ore, that are found in Hungary and Saxony, *viz.* 1. of a *red* colour; 2. of *purpliſh* or *violet*; and 3 of a *pale red* colour. *See the Spec.* 306 *of* Wallerius's Syſtem. Mineral.

Bomare deſcribes alſo the following arſenical ores of antimony, which, in all probability, are the ſame mentioned by Wallerius after himſelf, *viz.*

1. The *red* with parallel fibres, *ſtriis fere parallelis*, found at *Braunſdorff* in Saxony.

2. The *pale-red*, or of a *violaceous colour*, found at Preſbourg in Hungary, and another of a *blue* colour found alſo at Braunſdorff.

4. The *red* with the ſtriæ diſpoſed in a ſtarry form, found in Hungary and Saxony.

4. The *purple red*, which is plumoſe, or of very thin ſilky fibres, like *hair*, or wool: and ſometimes in a *dendritical* form, upon the white quartz of the grey ore of antimony, in the mine called the Old-Hope of God in Freyberg.

5. And the plumoſe ore of an *aſh colour*, which is alſo found of a purple-red colour, at Braunſdorff in Saxony.

Finally, the ſame author ſpeaks of a horn-antimony, *minera antimonii cornea*, which is ſaid to have been found at Stolberg.

[*e*] Beſides the colours of this ore mentioned in Sect. 274, there are alſo ores of the kind, which are *red* or *green*: and then they contain but a ſmall proportion of ſilver. Their texture is filamentous, very brittle and fuſible.

Theſe

D. With ſulphurated ſilver, copper, and arſenic. *See* Sect. 276 [*f*].

E. With ſulphurated lead. *See* Sect. 314.

Theſe ores may be analyſed by ſolution in *aqua regia*; both the regulus of antimony and the arſenic remain in the ſolution, and the ſulphur is ſeparated by filtration. If the ſolution be then boiled with twice its weight of ſtrong *nitrous acid*, the regulus of antimony will be precipitated on account of its dephlogiſtication; and, the arſenic which is then converted into an acid, will remain in the liquor, and may be procured by evaporation into dryneſs.

[*f*] If *ſilver* or *copper* be ſuſpected in the ſcoriæ, they may be analyſed by boiling in about 6 times their weight of of *dilute nitrous acid*, which will take up the ſilver and copper, and leave the regulus of antimony and the arſenic. Theſe laſt may be boiled in *ſtrong nitrous acid*, which dephlogiſticates the antimony, and the arſenic becomes ſoluble in water: ſo that the calx of antimony remains undiſſolved. The ſulphur may be found in a ſecond experiment, uſing *aqua regia* inſtead of the concentrated *nitrous acid*, and the ſilver may be precipitated with a clean plate of copper, previouſly weighed; for in this caſe, the ſilver precipitates upon it in its metallic form, which may be weighed, and its contents known. As to the copper, it may be precipitated by aerated mineral alkali; and 194 *gr.* of this precipitate well dried are equivalent to 100 *gr.* of copper in its metallic form. But from this laſt, the weight loſt by the copper plate, during the operation, muſt be ſubſtracted.

N. B. If in this ſolution by *aqua regia*, the precipitation of the ſilver ſhould be attempted by the *marine acid*, it would unite to the copper, and form a triple ſalt, which would alſo be precipitated together.

If the reſiduum ſhould caſually contain *ſulphur*, *arſenic*, and *iron*; by boiling it in the ſpirit of ſalt, the arſenic and iron will be taken up: the firſt (the arſenic), may then be precipitated by the addition of water, and the iron by the Pruſſian alkali, &c. *The Editor from* Kirwan, *p.* 327, 248 *and* 250.

SECT.

SECT. 372. (237.)

OBSERVATIONS on ANTIMONY [a].

By the name of Antimony is commonly underſtood the crude antimony, (which is compounded

[a] 1. Though the regulus of antimony is a metallic ſubſtance, of a conſiderably *bright white colour*, and has the *ſplendor*, *opacity*, and *gravity* of a metal; yet it is quite *unmalleable*, and falls into powder, inſtead of yielding or expanding under the hammer; on which account it is claſſed among the *ſemi-metals*.

2. Dr. Lewis mentions an eaſy proceſs to give a moſt brilliant metallic appearance to the regulus of this ſemi-metal. It conſiſts in throwing a lump of *cauk* (or *terra ponderoſa*) into the crucible, in which the antimony is melted in the fire; about one or two ounces of the *cauk* red hot will ſuffice for about 16 ounces of the melted ſemi-metal: and the fuſion being continued about two minutes more, on pouring it off, there will be found about 15 ounces of the regulus, as brilliant as *poliſhed ſteel*, or *pure quickſilver*.

3. Regulus of antimony is uſed in various metallic mixtures, as for *printing types*, *metallic ſpeculums*, &c. It enters into the beſt ſort of *pewter ware*.

4. It mixes with, and diſſolves various metals; in particular it affects iron the moſt powerfully; and, what is very remarkable, when mixed together, the iron is prevented from being attracted by the *load-ſtone*, as was mentioned in the note, N° 38, to p. 756.

5. It affects *copper* next, then *tin*, *lead*, and *ſilver*; promoting their fuſion, and rendering them all brittle and unmalleable; but will neither unite with *gold*, nor *mercury*; though it may be made to combine with this laſt by the interpoſition of

compounded of the metallic part and ſulphur) as it is melted out of the ore (Sect. 369.): and by the name of regulus, the pure ſemi-metal.

The

ſulphur. In this caſe it reſembles the common Æthiops, and is thence called *Antimonial Æthiops*.

6. Regulus of antimony readily unites with ſulphur, and forms a compound of a very faint metallic ſplendor: it aſſumes the form of long needles adhering together laterally: it is uſually formed naturally alſo in this ſhape. This is called *Crude Antimony*.

7. But though antimony has a conſiderable affinity to ſulphur; yet all the metals, except *gold* and *mercury*, have a greater affinity to that compound. If therefore *iron*, *copper*, *lead*, *ſilver*, or *tin*, be melted with antimony, the ſulphur will unite with the metal, and be ſeparated from the regulus, which, however, takes up ſome part of the metal, for which reaſon it is called *Martial Regulus*, *Regulus Veneris*, &c.

8. When gold is mixed, or debaſed by the mixture of other metals, it may be fuſed with antimony; for the ſulphur combines with the baſe metals, which, being the lighter, riſe up into ſcoria, while the regulus remains united at the bottom with the gold; which being urged by a ſtronger degree of heat, is freed from the ſemi-metal, which is very volatil. This method of *refining gold* is the eaſieſt of all. *See note* [*g*], *to p.* 518.

9. But the moſt numerous purpoſes, to which this ſemi-metal has been applied, are thoſe of the chemical and pharmaceutical preparations. Lemery, in his *Treatiſe on Antimony*, deſcribes no leſs than 200 *proceſſes* and *formulæ*; among which there are many good, and many uſeleſs ones. The following proceſſes deſerve to be mentioned on account of their utility.

10. Antimony melts as ſoon as it is moderately red hot, but cannot ſuſtain a violent degree of fire, as it is thereby diſſipated into ſmoke and white vapours, which adhere to ſuch cold bodies as they meet with, and are collected into a kind of *farina* or *powder*, called *Flowers of Antimony*.

11. If

The alchemiſts have made great uſe of antimony in their experiments; ſome of them chiefly on account of its being found in the Hungarian gold mines. Yet ſtill we know no more of

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11. If it be only moderately heated, in very ſmall pieces, ſo as not to melt; it becomes calcined into a greyiſh powder deſtitute of all ſplendor, called *Calx of Antimony*. This calx is capable of enduring the moſt violent fire; but at laſt it will run into a *glaſs* of a *reddiſh yellow colour*, ſimilar to that of the *Hyacinth*. The longer the calcination be continued, the more refractory it will be, and the leſs coloured the glaſs will become. The calcination of antimony may even be carried ſo far, that it will not vitrify, unleſs a ſmall portion of crude antimony be thrown into the crucible.

12. The following is the beſt method for avoiding diſappointment and perplexity in making this antimonial glaſs. Take any quantity of calx of antimony, made without addition, put it into a good crucible, which ſet in a melting furnace; kindle the fire gradually, and leave the crucible uncovered at the beginning; a quarter of an hour after the matter is red-hot, cover the crucible, and excite the fire vigorouſly, till the calx melts, which may be known by dipping into the crucible an iron wire, to the end of which a little knob of glaſs will adhere, if the matter be in perfect fuſion. Keep it ſo for a quarter of an hour, or rather longer, if the crucible can bear it; then take it out, and pour the melted matter on a ſmooth ſtone, made hot for the purpoſe, or in a proper mould, to give it the form of a cup, or of pills, called *Pilulæ Perpetuæ*.

The infuſion made of this coloured antimonial glaſs, in acidulous wine (ſuch as that of Bourdeaux) for the ſpace of 5 or 6 hours, is a very violent emetic.

13. If equal parts of *nitre* and *regulus of antimony* be deflagrated over the fire, the grey calx which remains is called *Liver of Antimony*.

14. If regulus of antimony be melted with two parts of *fixed alkali*, a maſs of a *reddiſh yellow* colour is produced, which being diſſolved in water, and any acid being afterwards added, a pre-

of the conſtituent parts of this ſemi-metal than the others, notwithſtanding all that has been written on the ſubject. Some ſay that

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cipitate is formed of the ſame colour, called *Golden Sulphur of Antimony*.

15. Fixed nitre, *viz.* the alkaline ſalt that remains after the deflagration of nitre, being boiled with ſmall pieces of regulus of antimony, the ſolution becomes reddiſh; and, on cooling, depoſits the antimony in the form of a red powder called *Mineral Kermes*.

16. Equal parts of the *glaſs*, and of the *liver* of antimony, well pulveriſed and mixed with an equal quantity of pulverized *cream of tartar*, being put into as much water as will diſſolve the cream of tartar, and boiled for 12 hours, adding now and then ſome hot water, to replace what is evaporated; the whole is to be filtered while hot; then being evaporated to dryneſs, the ſaline matter that remains, is the *emetic tartar*.

17. The regulus of antimony being pulveriſed, and diſtilled with *corroſive ſublimate* of *mercury*, a thick white matter is produced, which is extremely corroſive, and is called *Butter of Antimony*. This thick ſubſtance may be rendered limpid and fluid by repeated diſtillations.

On mixing the *nitrous acid* with this *Butter of Antimony*, a kind of *aqua regia* is diſtilled, called *Bezoardic Spirit of Nitre*.

18. The white matter that remains from this laſt diſtillation, may be rediſtilled with freſh nitrous acid; and the remainder being waſhed with water, is called *Bezoar mineral*, which is neither ſo volatile, nor ſo cauſtic as the *antimonial butter*. This butter being mixed with water, a precipitate falls to the bottom, which is very improperly called *mercurius vitæ*, for it is in fact a very violent emetic.

19. But if, inſtead of the *regulus*, *crude antimony* be employed, and the ſame operation be performed; the reguline part ſeparates from the ſulphur, unites to the mercury, and produces the ſubſtance which is called *Cinnabar of Antimony*.

20. The method of making *diaphoretic Antimony* has been already deſcribed in the note [*a*] to Sect. 366. p. 792. This pre-

that its earth is not vitrifiable, becauſe it is volatile, which is perfectly contrary to experience: and if volatility be the characteriſtic of a mercurial earth, the pipe clay

preparation excites animal perſpiration, and is a good *ſudorific*. The very ſame preparation of the *diaphoretic antimony* may be more expeditiouſly made, by *one* part of *antimony* with *two and a half* of *nitre*, mixed together and deflagrated: the reſidue of which is the mere *calx of antimony*, void of all *emetic power*.

21. And if the detonation be performed in a tubulated retort, having a large receiver, containing ſome water, adapted to it, both a *clyſſus* of antimony and the antimonial *flowers* may be obtained at the ſame time, as Neumann aſſerts.

22. When nitre is deflagrated with antimony over the fire, the alkaline baſis of the nitre unites with the calx of the ſemi-metal, which may be ſeparated by an acid, and is called *Materia Perlata*.

23. It is beyond any controverſy that this ſemi-metal acts on the human body as a violent (and ſometimes virulent) emetic, and as a ſtrong cathartic, impregnating vegetable acids, as *vinegar* and *acid-wines*, with theſe virtues, almoſt inexhauſtibly. By ſulphur, and by calcination with nitre, its malignity is abated, and its emetic power changed into a diaphoretic one. But as ſoon as it is reſtored to its pure metallic ſtate, it reſumes its virulence, which may be again deſtroyed, and again reſtored, and almoſt infinitely varied.

24. Hoffman has given an account of the different medicinal and pernicious effects of antimony, as ariſing from its different modes of treatment. *Crude antimony*, on account of the *regulus*, being corrected by the *ſulphur*, is not only ſafe, but in many caſes a medicine of great ſervice, both for the human ſpecies and other animals.

25. By ſimple fuſion it acquires a degree of malignity; but a far greater one if melted with half its weight of nitre, which conſumes nearly all the ſulphur, and leaves the regulus bare.

26. Mixed with common ſalt, and calcined over a gentle fire for ſeveral hours, and afterwards edulcorated with water,

clay from Cologne ought to be of the ſame nature. Perhaps it is better to ſay that the calx of antimony is volatile, and may both

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it yields an aſh-coloured grey calx, which is ſo fixed as to bear a melting heat, and proves a mild and ſafe diaphoretic, void of any malignant or emetic quality.

27. In the ſame manner, if calcined with a gentle fire in an earthen veſſel, uncovered and expoſed to the open air, it changes into an innocent calx, without the leaſt malignity. But if this very calx be melted with a ſtrong fire into glaſs, it becomes ſo active, that a few grains will occaſion violent vomiting and purging, or even mortal convulſions and inflammations.

28. Likewiſe, if the powdered regulus be calcined in a glaſs vial, over a ſand heat, for ſeveral days, it becomes a greyiſh ſalutary diaphoretic powder. But, if reduced to regulus, by fuſing it with powdered charcoal, nitre, and a little fat, it proves again virulent. Alſo, when antimony is melted with one fourth of its weight of ſalt of tartar, then powdered, the ſcoria ſeparated, and the more ponderous matter pulverized, the reddiſh powder thus obtained is ſalutary; but when it is melted with three or four times its weight of ſalt of tartar, both the ſcoria and the regulus are virulent.

29. Equal parts of antimony and nitre, melted together, yield a virulent maſs; but one part of antimony with 2 or 3 of nitre, makes an uſeful diaphoretic. The regulus melted with half its weight of nitre, continues emetic; but one part of regulus with two and a half of nitre becomes diaphoretic. Thus one preparation of antimony may be changed into another, a ſalutary into a poiſonous, and a poiſonous into a ſalutary one.

30. It is not yet aſcertained, ſays Macquer, in which of the principles of antimony its *emetic virtue* reſides. But it is evident, by what has been already aſſerted, that it cannot be aſcribed to its earthy part; for the calx of antimony, when entirely deprived of all phlogiſton, is not *emetic*, nor even *purgative*; as is evident from the effects of *diaphoretic antimony*, and the *pearly matter* of N° 22.

31 It is therefore equally evident, that this property of antimony depends upon the union of its metallic earth with its

be reduced into a metallic ſtate with phlogiſton alone, and melted into glaſs; and ſuch is its nature, though we do not know the reaſon of it.

SECT. 373. (238.)

Arſenic. *Arſenicum*, Lat.

General Properties of this Semi-metal.

5. Arſenic in its metallic form,

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its phlogiſton; and this appears to be the more probable; ſince by only re-combining phlogiſton with the earth of this ſemi-metal, totally deprived by calcination of all its *emetic virtue*, this very virtue is perfectly reſtored, and the regulus thus revived is no leſs *emetic*, than that which never underwent calcination.

32. After all that has been related in theſe notes, it is no wonder that antimony had been by many eſteemed an effectual poiſon: and by others the moſt extraordinary virtues, and great beneficial properties, have been attributed to the ſame ſubſtance. In 1566 its uſe was prohibited in France by an edict of the Parliament, which was repealed in 1650, antimony having a few years before, been received into the number of *purgatives*. In 1668 a new edict came forth, prohibiting its being uſed by any one but by the Doctors of medicine. Thus much is certain, 1ſt, that Antimony in its crude ſtate is not a poiſon, but a medicine of great efficacy; an excellent reſolvent and purifier of the animal juices, if given from 4 *grains* to half a drachm (or 30 *gr.*) together with abſorbents: 2dly, that it is capable of being rendered, by various operations and additions, either truly poiſonous, or more medicinal than in its crude ſtate: and, 3dly, that its moſt virulent preparations may, by ſlight management, be made ſalutary; and its moſt ſalutary ones virulent and deadly poiſonous, as Newmann obſerves. *The Editor.*

a. Is nearly of the ſame colour as lead, but brittle; and changes ſooner its ſhining colour in the air, firſt to yellow, and afterwards to black.

b. It appears laminated in its fracture, or where broken.

c. Is very volatile in the fire, burns with a ſmall flame, and emits very diſagreeable ſmell, like garlick [*a*].

It

[*a*] 1. If arſenic be laid on a red-hot iron, it burns with a ſlight flame, white ſmoke, and garlick ſmell: is wholly volatilized, and tinges a plate of copper, held over it, white.

2. The ſpecific gravity of the radical acid of arſenic, is = 3391; of white arſenic = 3,706; of its glaſſy ſtate = 500; and of its regulus = 8,301, or even = 8,310.

3. *Aqua Regia* and muriatic acid perfectly diſſolve arſenic; the *vitriolic*, however, requires to be boiling-hot. The *acetous* acid only acts upon its calx. The *nitrous* acid not only takes away as much phlogiſton as may be expreſſed by 109; by the loſs of which, the regulus is reduced to the ſtate of a calx; but, in a large quantity, aſſiſted by a proper degree of heat, it at length ſo far dephlogiſticates this calx, as to leave the acid of arſenic alone.

4. From analogy it is probable, that every metal contains a *radical acid* of a peculiar nature, which, with a certain quantity of phlogiſton, is coagulated into a metallic calx; but with a larger quantity, ſufficient to ſaturate it, forms a compleat metal. *Bergman's Sciagr.* See what has been ſaid on this ſubject, in the *Notes to p.* 307, 504, &c.

5. Gold, fuſed with arſenic in a cloſe veſſel, takes up ſcarcely $\frac{1}{66}$ of it; ſilver $\frac{1}{4}$; lead $\frac{1}{8}$; copper $\frac{5}{6}$; iron more than its own weight; biſmuth about $\frac{1}{15}$; zinc $\frac{1}{3}$; regulus of antimony $\frac{1}{3}$; and manganeſe an equal quantity.

6. Iron, by means of leſs than an equal quantity of *arſenic*, loſes its magnetic power. *Bergman's Sciag.* and the ſecond vol. of his eſſays, p. 283.

7. The arſenic, met with in commerce, is brought chiefly from the cobalt-works in Saxony, where zaffre is made.

Arſenic

d. It is, by reaſon of its volatility, very difficult to be reduced, unleſs it be mixed with other metals. However, a regulus may be obtained from the white arſenic, if it be quickly melted with equal parts of pot-aſhes and ſoap; but this regulus contains generally ſome cobalt, moſt of the white arſenic being produced from the cobalt ores during their calcination. The white arſenic, mixed with a phlogiſton, ſublimes likewiſe

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Arſenic is contained in great quantities in the cobalt-ores, from which it is driven off by long torrefaction: theſe fumes paſs into, and adhere to the ſides of, a very long chimney conſtructed for that purpoſe.

8. But the greateſt quantities are prepared at *Geyerſberg*, near the village *Ehrenfriederſberg* in Miſnia, from ores brought thither from *Schneeberg*, and other Saxon mines. The ore is thrown into a furnace reſembling a baking-oven, whoſe flew is an horizontal pipe, near an hundred fathoms in length, of a conſiderable width at the beginning, but growing narrower to the further end. The ore is every now and then ſtirred and turned over to promote the extrication of the arſenic, which ariſes in fumes into the pipe, and there condenſes into a greyiſh or blackiſh powder, called *Meal Arſenic*. This is refined by a ſecond ſublimation in cloſe veſſels, with a little pot-aſh, which detains the impurities: the force of the heat melts the ſublimed flowers into the cryſtalline maſſes, which are ſold all over Europe.

9. What is called arſenic is the calx of its regulus; and contains no *fixed air*. It is ſo far in the ſaline ſtate, as to be ſoluble in 80 parts of diſtilled water in the temperature of 59 degr. of Fahrenheit; but if the water be boiling, 15 parts will diſſolve one of the arſenical calx.

10. The regulus of arſenic is obtained from its calx, either by quickly fuſing it after it is made into a paſte, together with twice its weight of *ſoft ſoap*, and an equal quantity of mineral alkali, and pouring it out, when fuſed, into an hot iron cone; or by mixing it, in powder, with oil, to the conſiſtency

likewiſe into octohedral cryſtals of a metallic appearance, whoſe ſpecific gravity is 8,308.

e. The calx of arſenic, which always, on account of its volatility, muſt be got as a ſublimation, is white, and eaſily melts to a glaſs, whoſe ſpecific gravity is 5,000. When ſulphur is blended in this calx, it becomes of a yellow, orange, or red colour; and according to the degrees of colour is called *Orpiment* or *yellow arſenic*, *Sandarach*, *Realgar* or *red arſenic*, and alſo *Rubinus Arſenici*.

This

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conſiſtency of a ſyrup, and diſtilling the whole gradually to dryneſs. Towards the end, the regulus ſublimes, and may be made more perfect by a ſecond diſtillation in a matraſs, with its own weight of oil. This operation is too offenſive to be made but in the open air. After this ſublimation, the matraſs is broken, and a cruſt is found in the neck, having a glaſſy appearance, and a metallic luſtre. This glaſs, expoſed to the air, loſes its tranſparency, becomes milky, and blackens ſenſibly.

11. The calx of arſenic is the only metallic calx that diſſolves in water, and affords pyramidal cryſtals by ſlow evaporation. It unites with earths, by means of fuſion, and accelerates their vitrification; but all theſe glaſſes tarniſh ſoon by expoſure to air.

Boiling oils diſſolve this ſemi metal, as Kirwan aſſerts.

12. Arſenic is not attacked by *vitriolic acid* when cold; but when they are boiled together in a retort, ſome ſulphureous acid is produced, a little ſulphur ſublimes, and the arſenic is found in the form of a calx, but not at all diſſolved.

13. The *nitrous acid* attacks it violently, calcines it; and, by a gentle heat, a conſiderable part of this calx is diſſolved.

According to Bucquet, the *marine acid*, aſſiſted by heat, diſſolves arſenic, and its calx.

Both fixed and volatile alkalies precipitate the arſenic from this combination.

f. This calx and glaſs are diſſoluble in water, and in all liquids; though not in all with the ſame facility. In this circumſtance arſenic reſembles the ſalts, for which reaſon it alſo might be ranked in that Claſs, at Sect. 155.

g. The regulus of arſenic diſſolves in ſpirit of nitre; but as it it is very difficult to have it perfectly free from other metals, it has hitherto been very little examined in various menſtrua.

It

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14. The regulus of this ſemi-metal, mixed with nitre, and thrown into a red-hot crucible, occaſions a briſk detonation: but its calx, *viz. white arſenic*, does not ſenſibly deflagrate with nitre; and if the operation is made in an open veſſel, it alkalizes the ſalt.

15. A mixture of arſenic and ſulphur, being fuſed, produces either a *volatile yellow* compound, called *factitious orpin*, or *orpiment*; or a red one if the heat is briſk, called *Factitious Realgar*, *Rizegal*, or *Red Arſenic*. They are both volatile by fire, and may be decompoſed by *lime*, and by *alkalis*, which have more affinity to the ſulphur, than the arſenical calx. However, this *calx*, like the *acids*, may decompoſe the *livers of ſulphur*.

16. All the properties of this calx of arſenic, prove it to be a combuſtible body, which, on being united to *vital air*, aſſumes the character of a ſaline ſubſtance. By diſtilling a mixture of *dephlogiſticated marine acid* and of *calx* of *arſenic*, the *marine acid* attracts the phlogiſton from the calx; and this laſt paſſes into the ſtate of a true acid, as Scheele obſerved. He ſucceeded alſo in preparing arſenical acid, by diſtilling the calx of this ſemi-metal with four parts of nitrous acid. This laſt gives out much nitrous gas; and the calx aſſumes the character of an acid in a ſolid form, which muſt be very ſtrongly, and very long heated to diſengage the ſuperabundance of the nitrous acid. The proceſs for diſengaging this acid, which has been formerly deſcribed at p. 298, is nearly the ſame; and as to its properties, they have been expoſed already in Sect. 161.

What

b. It is poiſonous, eſpecially in form of a pure calx, or glaſs. But probably it is leſs dangerous when mixed with ſulphur, ſince it is proved by experience, that the men at mineral works are not ſo much affected by the ſmoke of this mixture, as by the ſmoke of lead; and that ſome certain nations make uſe of the red arſenic, in ſmall doſes, as a medicine.

i. It unites with all metals, and is likewiſe much uſed by nature itſelf to diſſolve, or, as

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17. What paſſes in theſe operations ſeems to countenance very well the new doctrine of the *Aerial Theory*. For the calx of arſenic, by its great affinity to *pure air* (which is the radical acidifying principle of thoſe acids), combines with it, and becomes an acid itſelf, in the ſame manner as they had been formed.

18. It was with great heſitation, that I have hitherto revolved the principles of the new theory in my mind, on account of my being deprived of the true key for unfolding the whole. But having been favoured within theſe few days, with the ſyſtem of the *New Nomenclature*, by the generous friendſhip of the Authors, I can but acknowledge its great ſuperiority (if well ſupported by *real facts*): and I rejoice on this valuable acquiſition to the philoſophical world, for explaining the operations of Nature in the moſt ſimple and intelligible way. I muſt keep, however, to the former language in the remainder of theſe notes, *ut pes et caput uni reddantur formæ*, according to the old adage of Horace.

19. The arſenical acid has a ſtrong taſte. It may be fuſed in the fire, and thus may be freed from the portion of the arſenical calx it happens to contain ſtill. It weakly reddens vegetable blue colours: expoſed to the air, it loſes its tranſparency, and gradually deliqueſces. This ſalt is ſoluble in two parts of water, combines eaſily with *lime*, but more difficultly with *ponderous* and *magneſian* earths. It forms neutral ſalts, when united to alkalis, which, however, may be decompoſed by *lime*, as Bergman aſſerts.

The

as we term it, to *mineralise* the metals, to which its volatility, and solubility in water, must greatly contribute. It is likewise most generally mixed with sulphur.

k. It absorbs, or expels, the phlogiston, which has coloured glasses; if mixed with them in the fire.

SECT. 374. (239.)

Native Arsenic.

Arsenic is found,

1. Native, *Arsenicum nativum*; called *Scherbencobolt* and *Fliegenstein* by the Germans.

It is of a lead colour when fresh broken, and may be cut with a knife, like compact black lead, but soon blackens in the air. It burns with a small flame, and goes off in smoke.

A. Solid and testaceous, *Arsenicum nativum particulis impalpabilibus testaceum. Scherbencobolt* [*a*].

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20. The acid of arsenic, by the addition of any phlogistic substance, becomes white arsenic; and, by the addition of still more, assumes the appearance of a perfect semi-metal, though apparently no states are more opposite than those of a liquid acid, and of a solid metallic substance. *The Editor from* Kirwan, Bergman, Fourcroy, &c.

[*a*]. The *regulus of arsenic* is found with a metallic form, in Bohemia, Hungary, Saxony, Hercynia, and else where, but particularly at St. *Marie aux mines*, in Alsatia, where not long since many hundred weight of it were extracted. In Germany

This is found in the mines of Saxony, the Hartz, and Hungary.

B. Scaly, *Particulis micaceis*, from Winorn at Kongſberg in Norway.

C. Friable and porous, *Friabile et poroſum. Fliegenſtein*, in German [*b*].

With

Germany it is called not only *Fliegſtain*, but alſo *Mucken-pulver*, viz. *flie-powder*; although it is difficult to gueſs for what reaſon this laſt name has been given to it, as this regulus is not ſoluble in water: and therefore, unleſs dephlogiſticated, it is not at all proper for the purpoſe alluded to by ſuch a name. Perhaps by ſome ſpontaneous calcination it became, one time or another, ſo much dephlogiſticated as to acquire a degree of ſolubility, which anſwered to that purpoſe.

As to its form, it is often found ſhapeleſs, friable, and pulverulent; but ſometimes compact, divided into thick convex lamellæ, with a needle-formed or micaceous ſurface. It admits of a poliſh, which, however, is ſoon loſt by it's being expoſed to the action of the air.

When freſh broken, it appears as if compoſed of ſmall needle-like fibres, of a leaden colour, which ſoon grows yellow, and by degrees blackiſh. In hardneſs it ſeems to exceed copper, and in brittleneſs it reſembles antimony. *Bergman, Diſſert.* 21. § 11.

The native regulus of arſenic is ſeldom, if ever, found in a cryſtalline form, and poſſeſſing all the properties of the arſenical regulus. It is ſometimes found mixed with various metals; and, it may be analyſed by ſolution in *aqua regia*. The ſilver, if any, will remain precipitated: the iron, of which it commonly contains a ſmall portion, will remain in the ſolution; and if a ſmall quantity of water be added after decantation, the calx of arſenic will be precipitated, and the iron will remain. The Editor from Kirwan.

[*b*]. Some of the proper ores of arſenic are of a *whitiſh*, and others of a *blackiſh* colour; and both ſorts have more or leſs of a ſparkling aſpect; the firſt are called *White Pyritæ*, or *Miſpickel*, the latter *Fliegenſtainertz*. They conſiſt moſtly of

1. With ſhining fiſſures, *Fiſſuris nitentibus.* from Annaberg in Saxony.

This is by ſome called *Spigel Cobolt* (*Minera cobalti ſpecularis*) according to their notions of the affinity of theſe metals to one another. However, there always remains after the volatiliſation of the Scherbencobolt, ſome calx, either of cobalt or biſmuth, and ſome ſilver, though in too ſmall a quantity to deſerve any notice.

SECT. 375. (240.)

Calciform Arſenical ore.

2. In form of a calx, *Arſenicum calciforme.*

A. Pure, or free from heterogeneous ſubſtances, *Calx arſenici nativa pura* [*a*]

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of arſenic, blended with a conſiderable proportion of earthy or ſtony matter, but with little, if any, mixture of any other metallic body, *Newmann*, p. 226.

[*a*] This calciform ore is a true mineraliſation of this ſemi-metal by the aerial acid.

It is called alſo Native *Calx of Arſenic*, and *Flos Arſenici* by ſome mineralogiſts.

It does not detonate with nitre, though an effervescence ariſes.

Its ſpecific gravity is from 3,706 to 5000.

Is ſoluble in about 70 or 80 times its weight of water in the temperature of 60 *degr.* of Fahrenheit's thermometer.

But in boiling water, 15 or 20 times its weight are ſufficient to diſſolve it.

The ſolution turns tincture of turnſole *red*: and ſyrup of violets *green*.

It is ſcarcely ſoluble in the *vitriolic* acid; ſomething more in the *marine*, and moſt perfectly in the diluted *nitrous* acid. *The Editor from* Kirwan

Looſe

1. Looſe or powdery. This ſort is found at Gieſshubel in Saxony, but it is collected in a much purer ſtate on the ſides of the rock in ſome mines.

2. Indurated or hardened. This is found in form of white ſemi-tranſparent cryſtals, in ſmall cavities within the Scherbencobolt, at Andreaſberg in the Hartz, and in Saxony, but it is very ſcarce.

SECT. 376. (241.)

Sulphurated Arſenic. Orpiment. [*a*].

A. Mixed with ſulphur, *Calx arſenici ſulphure mixta.*

1. Hardened.

a. Yellow. Orpiment, *Auripigmentum*, from Hungary [*b*].

Red,

[*a*] The orpiment may perhaps be found naturally in looſe ſcaly powder, as it is ſometimes met with in the ſhops. However, I have only ſeen the hardened ſort in collections. *The Author.*

[*b*] Orpiment is naturally found in the earth; in general it is amorphous, and very ſeldom cryſtallized. Baron Borne once found it in a polyhedral form on a blue clay in Hungary.

It is generally compoſed of ſhining, flexible laminæ like *mica*, more or leſs ſolid.

Its ſpecific gravity is about 5,315. It burns with a blue flame, and contains only about *one tenth* of its weight of ſulphur.

Some pretend that orpiment, on account of the ſulphur it contains, has no poiſonous qualities, and may ſafely be

b. Red, Native Realgar or Sandarach, from Hungary, Andreasberg in the Hartz, Saxony, and Rotendal in Elfdalen in Sweden [*c*].

SECT. 377. (242.)

Arsenic mixed with metallic calces.

C. Mixed with the calx of tin, in the tin-grains. Sect. 299, (181) and 301.

D. With sulphur and silver, in the Rothgulden, or red silver ore, Sect. 270 and the 5 following.

E. With calx of lead, in the lead-spar. Sect. 308.

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be used intetnally; but Maquer very positively asserts the contrary, and gives a very serious warning against its use, even if the orpiment be truely native. *The Editor from* Fourcroy *and* Kirwan.

[*c*] The *red-arsenic*, or *realgar*, called otherwise *Rawschgelbe* by the Germans, is found in irregular, or stalactitical masses.

It is either opake, or semi-transparent; sometimes it is found transparent, and regularly crystallized in octohædral pyramids, or prisms; in this last form it is called *Ruby of Arsenic*.

Its specific gravity is = 3,225.

It contains 16 parts of sulphur *per* hundred weight.

Nitrous acid soon destroys its redness.

To analyse these ores, they should be digested in *marine acid*, adding the *nitrous* by degrees to help the solution. The sulphur will be found on the filter; and the arsenic will remain in the solution, from which it may be precipitated in its metallic form by zinc, adding spirit of wine to the solution. *The Editor from* Kirwan.

F. With calx of cobalt, in the efflorescence of cobalt. Sect. 384.

SECT. 378. (243.)

Mineralised Arsenic.

3. Mineralised arsenic, *Arsenicum mineralisatum.*
A. With sulphur and iron, *Arsenicum ferro sulphurato mineralisatum.* Arsenical pyrites or marcasite [*d*].

This alone produces red arsenic, in roasting: and is found in great quantities in the mines of Lofas in the province of Dalarne. It is of a deeper colour than the following.

B. With iron only, *Arsenicum metalliforme ferro mixtum. Mispickel* [*e*]. This differs with regard to its particles, being

1. Steel-grained;
2. Coarse-grained, from Westersilverberget;

[*d*] These kinds in Cornwall are called Silvery or White Mundics, and Plate Mundics. *D. C.*

[*e*] The mineral, commonly called *Mispickel*, is justly reckoned a regulus of arsenic, as, when totally deprived of sulphur, it consists of iron and arsenic united in a metallic form: and although the iron amounts to $\frac{1}{3}$, or sometimes even to $\frac{2}{3}$, yet the compound is not *magnetic*, but if ignited, sends forth an arsenical smell, and is soon rendered magnetic, though the operation be performed on a tile, without any phlogiston. See note *d* to p. 741. It easily flows in the fire; and, in close vessels, the greater part of the regulus rises, leaving the iron to the bottom. A compound of this kind may also be artificially made. *Bergman*, De Arsenico, § 2.

Crystallized

3. Criſtalliſed.
a. In an octohedral figure. This is the moſt common kind.
b. Priſmatical, from the mines of Salberg, Weſterſilfverberget, and Hellefors in Weſtmanland, and in many places of foreign countries [*f*].

SECT. 379. (244.)

Arſenic Mixed with metals.

C. With cobalt, in almoſt all cobalt ores. Sect. 382. 384. and 386.
D. With ſilver. Sect. 271 and following.
E. With copper. Sect. 327.
F. With antimony. Sect. 370.

SECT. 380. (245.)

OBSERVATIONS on ARSENIC [*g*].

Such ores as conſiſt of arſenic united ſolely with iron, or with iron and ſulphur, cannot be

[*f*] The ſulphureous marcaſite is added to this kind, when *red arſenic* is to be made; but in Sweden it is ſcarcer than the ſulphureons arſenical pyrites. *The Author.*

[*g*] 1. It can hardly be doubted, that arſenic may be applied to valuable purpoſes in medicine; as various experiments have proved in different applications. But, in reſpect both

be employed to any other uſe than to the preparation of arſenical products; for which reaſon they ought to be ranged among the arſenic ores. Some have indeed denied this difference between the arſenical pyritæ; but it is however neceſſary to make ſome difference, with reſpect to the preſence or abſence of ſulphur, although the greateſt quantity of arſenic is got from the calcination of the cobalt ores, and that the true arſenical pyritæ do not deſerve to be ſeparately employed.

Although

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both to its doſe and preparation, the utmoſt caution muſt be uſed, for it is beyond any diſpute that arſenic is the moſt virulent of all poiſons, and that, even when externally applied, it often produces very pernicious effects.

2. Phlogiſton and alkalis ſeem to be the beſt correctors of the corroſive acrimony of arſenic; and may be applied to obviate its deleterious effects. It was thought of courſe, that the *neutral arſenicated ſalt* of Macquer, being ſaturated with the vegetable alkalis, would not produce thoſe noxious effects; but Mr. de Morveau aſſerts, that upon trial this neutral ſalt is in fact a very ſtupifying poiſon.

3. Hence too it appears, ſays Bergman, why *realgar* is leſs noxious, why the regulus is milder than white arſenic, and this again milder than the *dry acid:* why the baths of *Carſbad*, which contain a *mineral alkali* only, united with aërial acid, are extremely uſeful in diſeaſes occaſioned by arſenic: why *arſenic*, taken internally without the neceſſary correction, occaſions, by its irritating quality, convulſive motions, among other ſymptoms, both in the ſtomach and other parts of the body.

4. Of all metals arſenic moſt eaſily loſes its phlogiſton; we therefore ſhould be cautious in confiding to phlogiſtic correctors, as the phlogiſton may be ſeparated in the viſcera by many different ways.

5. The ſymptoms of ſuch as in a fit of deſpair, have taken a doſe of arſenic, begin to appear in about half an hour

Although it is difficult to reduce the arſenic by way of precipitation, one cannot for that reaſon deny it to be of a metallic nature; for the ſame reaſoning might have been uſed againſt the exiſtence of zink in the calamine, before the method to extract that ſemi-metal in its metallic ſtate, now known, was diſcovered. But thoſe who know that metals only can be mixed with metals, ſo as to preſerve the ſolidity and ſome ductility in the compound, and who at the ſame time are ignorant of any metallic earth which cannot be reduced to its metallic ſtate again, could never entertain ſuch notions.

It is indeed true, that ſulphur, in regard to the brittleneſs which it produces in metals, is of

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hour after, by a nauſea, ſickneſs, and reaching; theſe are followed by violent vomitings, hiccups, and pains in the ſtomach and bowels: convulſions and palſies in the limbs, intenſe heats, cold ſweats, and palpitations of the heart, extreme anxieties, reſtleſsneſs, proſtration of ſtrength, thirſt and dryneſs of the mouth and throat, loſs of reaſon, and at laſt death. If the quantity taken has been conſiderable, the ſtomach and inteſtines are found, upon diſſection, corroded and perforated; though in general the patient expires before the further action of the poiſon can take place: and the moſt experienced phyſicians acknowledge, that no antidote can overcome the deſtructive efficacy of this poiſon.

6. A preparation of arſenic with nitre has been once highly extolled, as a febrifuge, at Berlin; but arſenic, however prepared, continues to retain its poiſonous quality. Even the external application of this ſubſtance has produced many times the moſt dangerous conſequences: and Doctor Mead has ſhewn that the uſe of arſenic, as an antipeſtilential pre-

of no worſe effect than arſenic; but this laſt may by itſelf, and mixed only with a pure phlogiſton, be ſublimed into a metallic form, which is more plainly ſeen in the Scherbencobolt (Sect. 374.). I eaſily perceive that it may be objected by thoſe who deny arſenic to be a ſemi-metal, that it may as well be a ſalt of a peculiar nature; as, for inſtance, the vitriolic acid is; and that it may, like ſulphur, diſſolve the metals in form of a kind of regulus; and farther, that its aſſuming a metallic appearance, when it is united with an inflammable ſubſtance, is of no conſequence; ſince there are fiſh and inſects who have a ſhining metallic colour: to this little can be anſwered, ſince it has been already agreed, that ſyſtems muſt not be too ſeverely criticiſed.

SECT.

ſervative among the Arabians, is grounded on a miſtake of the word *darſini*, which is nothing elſe but a preparation of cinnamon with other aromatics, &c.

7. The *philothrum Turcicum*, or pomatum of Turky, contains orpiment, among others ſubſtances; but its depilatory power is perhaps more properly aſcribed to the cauſtic alkali.

8. Philoſophers evince the extraordinary poroſity of bodies, and the wonderful ſubtility of vapours, by the ſympathetic ink. This is compoſed of *cauſtic fixed alkali*, boiled in water with orpiment, which yields a fœtid hepatic ſolution, in which ſtate it is uſed as ſuch. Orpiment, alſo, boiled in water, with double the weight of quicklime, affords a *probatory liquor*, which may be employed for proving wines; for when they are naturally acid, or grown ſo by age, the owners ſtill dare to continue to edulcorate them, with ſugar of lead; notwithſtanding the puniſhment of the law, if detected; but ſome drops of this probatory liquor being thrown into a glaſs

SECT. 381. (246.)

6. Cobalt. *Cobaltum.*

Its general properties [*a*].

6. This ſemi-metal is,

a. Of a whitiſh grey colour, nearly reſembling fine hardened ſteel,

Is

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glaſs of ſuſpected wine, if it is adulterated, a *brown* or *black ſediment* will be precipitated: otherwiſe, if the wine is pure, it will occaſion nothing but a *yellow precipitate*.

N. *B*. A large proportion of tartar in the wine, will render the probatory liquor ineffectual; as the tartarous acid will form with the lime a *white ſalt*, very difficult of ſolution.

Mountain-cryſtals placed over *orpiment*, *white arſenic*, *crude antimony*, and *ſal ammoniac*, mixed in a crucible, are tinged by means of heat, with a beautiful red, yellow, and *opal colours*, as Neri has deſcribed; but they very often crack in the operation.

In painting likewiſe the artiſts employ arſenic. Painters in oil, frequently uſe *orpiment* and *realgar*, and a beautiful *green* pigment may be precipitated from blue vitriol, by means of white arſenic diſſolved in water, together with vegetable alkali. This, prepared with water or oil, affords a colour which ſuffers no change in many years; but muſt not be applied to any kind of ſweetmeats, or food, as it is really very poiſonous. *The Editor from* Bergman, Kirwan, &c.

N. B. Arſenic whitens fuſed copper. *See note* [*b*], *p.* 711.

[*a*] The colour of regulus of cobalt is rather of a blueiſh grey; and its ſpecific gravity is about = 7,700.

Its fuſibility is like that of copper, or even gold; and, when well purified, it is hardly eaſier to melt than iron.

If melted cobalt is ſlowly cooled, it cryſtalliſes, forming in its ſurface ſmall bundles of needles, or needle-form priſms,

b. Is hard and brittle, and of a fine grained texture; hence it is of a duſky, or not ſhining appearance.

c. Its ſpecific gravity to water is 6000 :: 1000.

d. It is fixed in the fire, and becomes black by calcination; it then gives to glaſſes a blue colour, inclining a little to violet, which colour, of all others, is the moſt fixed in fire.

e. The concentrated oil of vitriol, aqua fortis, and *aqua regia*, diſſolve it; and the ſolutions become red. The cobalt calx is likewiſe diſſolved by the ſame menſtrua, and alſo by the volatile alkali, and the ſpirit of ſea-ſalt.

When

laid on one another, and united into bundles. Mongez obſerved, that they greatly reſemble a maſs of ſhaken baſaltes.

In order to ſucceed in this cryſtallization, it is ſufficient to fuſe cobalt in a crucible, till it ſuffers a kind of ebullition; and, after having taken it from the fire, to incline the veſſel, while the ſurface of the ſemi-metal is congealing. By this inclination the portion ſtill fuſed is poured out, and that which adheres to the ſides of this kind of geode, formed by the cooling the ſurfaces of the cobalt, is found covered with the cryſtals ſought for.

Melted with borax it affords a *blue* glaſs, which is the moſt obvious property for diſtinguiſhing its ores amongſt all others.

It is difficultly calcined; and

Its calx, although it appears black, is in fact of a very deep blue.

This calx is not volatil; and being melted with borax, or potaſh, and ſiliceous ſand, it produces a blue glaſs, called *ſmalt*.

The regulus of cobalt is eaſily ſoluble in *ſpirit of nitre*, and *aqua regia*.

f. When united with the calx of arſenic in a ſlow (not a briſk) calcining heat, it aſſumes a red colour. The ſame colour is naturally produced by way of efflorescence, and is then called the *bloom* or *flowers of cobalt.* When cobalt and arſenic are melted together in an open fire, they produce a blue flame.

g. It does not amalgamate with quickſilver by any means hitherto known.

b. Nor does it mix with biſmuth, when melted with it, without addition of ſome medium to promote their union.

The colour of this ſolution, as well as that made in any of the other acids, and in *volatil alkali*, is either *red* or of a *roſe-colour.*

This ſolution, diluted with water, is a ſympathetic ink, as the writing with it does not appear when dry; but, on being moderately warmed, it becomes of a fine green colour.

Its precipitate, by common or phlogiſticated alkali, is of a reddiſh-aſh colour.

It difficultly diſſolves in *vitriolic* acid; and ſcarce at all in the *marine*, unleſs heat be employed. The *marine* ſolution is a ſympathetic ink, and it is on account of the *marine* part in the *aqua regia*, that the above ſolution has the ſame property.

The calx, however, of this ſemi-metal is more eaſily diſſolved by theſe acids, and yields even to the *acetous* acid.

It is worth notice that the red colour of the acid ſolutions of cobalt when diluted with water, inſtead of fading, ſeems to become more vivid.

Cobalt does not combine by fuſion with ſilver, biſmuth, or lead.

It is moſt ſtrongly attracted by the acid of ſugar, which precipitates it from the other acids, in the form of a pale roſe coloured powder.

The acid of ſorrel, alſo precipitates cobalt from the muriatic and other acids. *The Editor from* Bergman, Kirwan, *and* Fabroni.

SECT.

SECT. 382. (249.)

Native Cobalt [*b*].

B. 1. With arſenic and iron in a metallic form, *Cobaltum ferro & arſenico metalliformi mineraliſatum*; *vulgò* Cobaltum *dictum*.

This

[*b*] Pure native cobalt has not yet been found: that which paſſes for ſuch, according to Kirwan, is mineralized by arſenic. Bergman, however, in his *Sciagraphia*, has entered this preſent ore, under the denomination of *native cobalt*: and certain it is, that among all the cobaltic ores, this is the neareſt to the *native* ſtate of this ſemi-metal. It always contains a ſmall quantity of iron, beſides the arſenic, by which it is mineralized.

This is generally called the *Grey Cobalt Ore*, and Glantz-cobalt, or *Stahl Derben Cobalt*, by the Germans; and, beſides the places mentioned by the author, it is alſo found in ſome parts of England, particularly at Mendip Hills in Somerſetſhire, and in Cornwall, in which laſt country Dr. Lewis aſſerts it to have of late been dug out in conſiderable quantities. Klaproth, in his account of the foſſils of Cornwall, aſſerts, that at Dolcoth in this laſt country, the grey cobalt ore is found either without, or with biſmuth; he adds, that it reſembles very much in colour, fracture, and other external appearances, the cobalt-ores from Rappold at Schneeberg, in the diſtrict of Miſnia in Saxony: and having made various and repeated trials of theſe Engliſh cobaltic ores, he found them to produce the fineſt blue colours, when properly vitrified.

An arſenicated grey cobalt ore, combined with galena, was found alſo in the year 1783, by Mr. Brolman, at Chatelaudren; as it is aſſerted in *Journal, de Phyſique* for Sept. 1787, p. 177.

This

This is of a dim colour when broken, and not unlike ſteel. It is found

a. Steel-grained, from Loos in the pariſh of Farila, in the province of Helſingeland, and at Schneeberg in Saxony.

b. Fine grained, from Loos.

c. Coarſe-grained.

d. Criſtalliſed.

1. In a dendritical or arboreſcent form, from Schneeberg.
2. Polyhedral, with ſhining ſurfaces; the *Glanzkobolt* of the Germans, from Schneeberg.
3. In radiated nodules, from Kongſberg in Norway.

SECT.

This ore is of a ſolid, heavy, and compact texture. Sometimes of a dull, and ſometimes of a bright appearance; frequently cryſtallized in a teſſelar, and ſometimes in a dendritical form,

And in general is ſo hard as to give fire with ſteel; and an arſenical ſmell is then perceived.

It grows black in the fire; is ſoluble with effervescence in *nitrous acid*, from which it may be precipitated by the *marine*; and affords the ſympathetic ink, mentioned already in the notes to Sect. 381.

In order to diſtinguiſh this from the arſenical ores of the ſame appearance, the two principal characters of cobalt, *viz.* the ſympathetic ink, and the blue colour given to glaſs, are fully ſufficent.

It is analyſed by ſolution in *aqua regia*, or *nitrous acid*, and evaporation to dryneſs. The reſiduum treated with the acetous acid will yield to it the cobaltic part; but the arſenic ſhould be firſt precipitated by the addition of water.

Or elſe this ore may be firſt roaſted to expell the arſenic; and then if treated with *nitrous acid*, the cobalt will be diſſolved with the ſmall portion of iron; and, by boiling the ſolution,

SECT. 383. (247.)

Calciform Cobalt [*a*].

The cobalt is moſt commonly found in the earth mixed with iron.

A. In form of a calx, *Cobaltum calciforme.*

1. With iron without arſenic, *Martiale abſque arſenico.*

ſolution, moſt of the iron will be precipitated: by adding fixed alkali, the remainder of the iron will be firſt precipitated *yellowiſh*, and afterwards the cobalt will fall down of a reddiſh colour.

The Pruſſian alkali may alſo be employed, to precipitate firſt the *iron* of a blue colour, and afterwards the cobalt *reddiſh*, or rather *grey*. The Editor from *Bergman*, *Kirwan*, *Mongez*, &c.

[*a*] This ore ſeems to be the aerated cobalt of Kirwan, p. 336 of his *Elem. of Mineralogy*.

It is called the *Black Ore of Cobalt*, *Vitreous Ore*, Kobalt Mulmum, and Schlaken-Kobalt, by the Germans.

It is found in a looſe, powdery form. Sometimes reſembling *lamp-black*, either grey or blackiſh, and then called *Cobalt Ochre*.

When in black indurated ſcoriform maſſes, it is called *Schlaken Kobalt*, or Vitreous Cobalt. They are free from ſulphur and arſenic; and if theſe be preſent, they are only mechanically mixed.

A ſmall portion of copper and iron is alſo ſometimes found in it.

This ore is frequently imbodied in ſtones, or ſands of a black colour. Talc, chalk, and gypſum, impregnated with it, are called by the ſame name; and by ſome *Spiegel Cobalt*. It is ſometimes alſo contained in ſome green and blue earths of the argillaceous kind. *Kirwan*, p. 336.

Looſe

a. Looſe or friable, *Minera cobalti calciformis pulverulenta.* Cobalt ochre, *Ochra cobalti nigra.* It is black, and reſembles the artificial zaffre.

b. Indurated, *Minera cobalti calciformis indurata. Minera cobalti vitrea,* the *ſchlacken* or ſlag cobalt.

This is likewiſe of a black colour, but of a glaſſy texture, and ſeems to have loſt that ſubſtance which mineraliſed it, by being decayed or withered. It is often confounded with the Scherbencobolt, for it is ſeldom quite free from arſenic; and there may perhaps exiſt a progreſſive ſeries from the Schlacken kind to the Scherbencobolt kind (of Sect. 374.).

SECT. 384. (248.)

2. *Combined with Arſenical Acid* [*d*].

This ore is the *Minera cobalti calciformis acido arſenici mixta:* or *Cobalt-blut.*

[*d*] This ore is found alſo either *looſe* and *pure*; or mixed with *chalk* or gypſum; or indurated and cryſtallized in tetrahedral cryſtals; or in a ſtalactitical form.

It melts eaſily, and then becomes blue.

It frequently inveſts other cobaltic ores: and is found ſometimes in ſtone and ſand. Bergman has ſhewn that the arſenical *acid*, and not the *calx* of arſenic, as the text erroneouſly expreſſed, enters into this combination; for cobalt is never *red* but when united to an acid. Kirwan, p. 337.

Flowers of cobalt, mineralized by arſenic, without any ſilver, and intermixed with galena, were diſcovered, on the mountain near the village of Aténe, by Mr. Schreiber. *See* Journal de Phyſique *for September* 1787, p. 177.

Ochra

Ochra cobalti rubra, Bloom, Flowers, or Efflorescence of cobalt.

a. Loose or friable, *Ochra cobalti pulverulenta.* This is often found of a red colour like other earths, spread very thin on the cobalt ores: and is, when of a pale colour, erroneously called Flowers of Bismuth [*e*].

b. Indurated, *Ochra cobalti rubra indurata.* Hardened Flowers of Cobalt.

This is commonly crystallised in form of deep red semi-transparent rays or radiations: It is found at Schneeberg in Saxony.

SECT. 385. (250.)

Cobalt with sulphurated iron, Cobaltum ferro sulphurato mineralisatum [*f*].

This ore is of a lighter colour than the preceding, nearly resembling tin or silver. It is found,

[*e*] A white cobalt-earth, or ochre, is said to have been found. It has been seen and examined by a celebrated mineralist, who found it in every respect, except the colour, to resemble the cobalt flowers; and it is very possible, that those cobalt flowers might in length of time have lost their red colour, and become white. *The Author.*

[*f*] This ore is sometimes found in large masses, and sometimes in grains crystallised, of a dull white colour, and frequently bears the appearance of *Mispickel.* It has no mixture of arsenic.

It becomes *black*, and not *red*, by calcination, which distinguishes it from pyrites. And it contains so little sulphur that none can be extracted from it.

When dissolved in *aqua regia* its solution is *yellow* while cold, but when boiling becomes *green*, which alternation of colour is peculiar to *marine cobalt.* The Editor from Kirwan, p. 349.

a. Crystallised

a. Cryſtalliſed.

1. In a polygonal form.

a. Of a ſlaggy texture.

b. Coarſe-grained.

This kind is found in Baſtnasgrufva at Raddarſhyttan in Weſtmanland, and diſcovers not the leaſt mark of arſenic. The coarſe-grained becomes ſlimy in the fire, and ſticks to the ſtirring hook during the calcination in the ſame manner as many regules do. It is a kind of regule prepared by nature.

That ſort which is of a ſlaggy texture is very martial, and is deſcribed by the mine-maſter Mr. Brandt, in the Acts of the Swediſh Academy of Sciences for the year 1746. Both theſe give a beautiful colour.

SECT. 386. (251.)

Combined with ſulphurated and arſenicated iron [g].

3. With ſulphur, arſenic, and iron, *Cobaltum cum ferro ſulphurato et arſenico mineraliſatum.*

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[g] This ore has a great reſemblance to the *Stahl derben Kobalt*, mentioned in the note to Sect. 382: but it is ſofter, for it never ſtrikes fire with ſteel, and may ſometimes even be ſcraped with a knife.

It moſtly appears under ſome polygonal form.

The moſt ſhining ſorts of this ore, and of the former ſpecies, have been called *Cobalt Glantz.*

It is analyſable like the other cobalt ores, and the ſulphur may be caught in the filter. Kirwan, p. 339.

This

This reſembles the arſenicated cobalt ore, being only rather of a whiter or lighter colour. It is found

a. Coarſe-grained.

b. Cryſtalliſed.

1. Of a polygonal figure, with ſhining ſurfaces, as the *Glanzkobolt* pag. 827.

It occurs at Tunaberg in the province of Sodermanland, partly of a white or light colour, and partly of a ſomewhat reddiſh yellow.

SECT. 387. (252.)

4. With ſulphurated and arſenicated nickel and iron.

See *Kupfernickel* in Sect. 256 of the Author

SECT. 388. (253.)

OBSERVATIONS on COBALT [*b*].

Since the glaſs of cobalt, which has been entirely freed from all arſenic in the calcination,

[*b*] The great conſumption to which cobalt is employed, conſiſts only in the application of the permanent blue colour it affords to glaſſes and enamels, either upon metals, or on porcelains, and earthen wares of all kinds. It is alſo the ſame *blue*, prepared in a very cheap way by the Dutch, from the coarſe zaffre, or blue glaſs of cobalt chiefly, and called *Azur de Hollande* by the French, which is employed by laundreſſes. But, although cobalt is applied to hardly any other purpoſes, theſe alone, render very profitable this ſemi-metal to the happy poſſeſſors

tion, and from the iron and the other metals by ſcorification, as when it is prepared from criſtalliſed cobalt flowers, may by addition of phlogiſton be melted to a true cobalt regulus, which differs in its qualities from all other metals; there can be no reaſon for denying the cobalt a place among the ſemi-metals, as many authors even at this time do, notwithſtanding the ſeveral reaſons given, which might induce them to examine nearer into the ſubject.

It was the Mine-maſter Mr. Brandt who firſt diſcovered this ſemi-metal, and deſcribed it in the abovementioned Hiſtory of Semi-metals, in the *Acta Upſalienſia* for the year 1735.

The

poſſeſſors of its mines, if they are productive enough of its ore, to be worked on a large ſcale.

Ores of cobalt are found in ſeveral parts of Europe; the moſt plentiful are worked near Schneeberg, in the diſtrict of Miſnia in Saxony; alſo at St. Andreaſberg in the upper Hartz, where large quantities have been met with for upwards of 30 years paſt. Some centuries ago there was but an iron ore in this laſt place; but, about the beginning of the fourteenth century, on ſinking deeper, it was ſucceeded by a very rich ore of ſilver. This alſo being at length exhauſted, gave place to cobalt-ores. Some pieces are ſometimes found in theſe mines that contain ſilver and gold. Theſe metals, however, are only accidental, and not eſſential, as ſome raſhly ſuppoſe, to the exiſtence of cobalt ores.

The general method of preparing cobalt ores in the large way ſeems confined to Saxony alone, from whence all other parts of the world, even the Eaſt-Indies, are conſtantly ſupplied. It is ſuppoſed that the Chineſe and more particularly the Japaneſe, had formerly mines of excellent cobalt, with which

The brittleneſs of the cobalt regulus is no proof againſt its being a ſemi-metal; that property being the baſis on which the diſtinction between the ſemi-metals and metals is founded. The earth of cobalt is fixed and vitrifiable in the fire, as well as that of copper and iron; and the colour of its glaſs being ſo immutable in the fire, proves it to be a particular ſubſtance, diſtinct from other earths and metallic calces.

The experiment of making a cobalt glaſs from iron or ſteel and arſenic, will certainly never ſucceed, unleſs the arſenic, employed for that purpoſe, has been made from a cobalt ore; but if the origin of the colour ſhould be aſcribed

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the fine blues of their ancient porcelanes were painted; but it appears that theſe mines are now exhauſted; and that the inferior blues of their preſent wares are painted with the Saxon zaffre, imported to them by the Dutch.

In regard to the management of this article at large, as employed in Saxony, the following is the abſtract. The cobalt taken out of the mine, is broken with hammers into pieces, about the ſize of an hen's egg; and the ſtony involucrum, with ſuch other heterogeneous matters as are diſtinguiſhable by the eye, are ſeparated as much as poſſible. The choſen mineral is then pounded in ſtamping mills, and ſifted through braſs wire ſieves. The lighter parts are waſhed off by water, and it is afterwards calcined in a large flat-bottomed arched furnace, reſembling a baking oven, where the flame of the wood reverberates upon the ore: this is occaſionally ſtirred and turned during the calcination, with long handled iron hooks or rakes; and the proceſs is continued till it ceaſes to emit any fumes. The oven or furnace is terminated by a long horizontal gallery, which ſerves for a chimney; in which the calx of arſenic, naturally mixed with the ore, ſublimes, condenſes, and is fuſed into a glaſs, which is ſold,

in

aſcribed to an irreducible metallic earth, there is no occaſion for this experiment; becauſe a cobalt regulus may be prepared ſo as to be free both from arſenic and iron, the preſence of this laſt metal being eaſily diſcovered by the loadſtone.

It is therefore now unneceſſary and ridiculous to continue the old definitions of the cobalt, in which the Speiſe, which partly is a cobalt regulus, and partly a compound, conſiſting of nickel, cobalt and biſmuth, united with ſulphur and arſenic, is either confounded with the ſemi-metal itſelf, or quoted as a proof, that cobalt regulus cannot exiſt in any other manner than as a dead earth involved in heterogeneous

in commerce, by the improper name of *White Arſenic*. If the ore contains a little *biſmuth*, as this ſemi-metal is very fuſible, it is collected at the bottom of the furnace. The cobalt remains in the ſtate of a dark grey calx called *zaffre*. One hundred pounds of the cobalt ore loſe 20 and even 30 *per cent.* during this operation, which is continued 4 or even 9 hours, according to the quality of the ore. The roaſted ore being taken out from the furnace, ſuch parts as are concreted into lumps, are pounded and ſifted afreſh. This roaſted powder of cobalt is the true zaffre. But the zaffre in the commerce is never pure, being mixed with two. or rather three parts of powdered flints. A proper quantity of the beſt ſort of theſe, after being ignited in a furnace, are thrown into water, to render them friable, and more eaſily reduced to powder, which, being ſifted is mixed with the zaffre, according to the before-mentioned doſe: and the mixture, is put into caſks, after being moiſtened with water. This is the ſubſtance commonly ſold under the name of *zaffre*.

As to *ſmalt* it is no more than a vitrification of one part of the *calcined cobalt*, fuſed in a large crucible with two of *flint-powder*, and one of *pot-aſh*.

heterogeneous ſubſtances; which is the ſame as to conclude, that no pure copper can be produced from the copper regules or fuſions, called *Trotiſten* or *Spurſten*.

Theſe falſe notions have, however, induced a late author to deſcribe the cobalt as a mixture of iron, copper, lead, biſmuth, and arſenic; but he has not at the ſame time publiſhed any experiments which might ſerve to confirm his opinion; amongſt which, with great reaſon, ſuch experiments are expected as imitate nature in this compoſition, which is pretended to conſiſt of ſo many different things. It might then have been calculated, whether it would be profitable to eſtabliſh manufactures for making

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At the bottoms of the crucibles in which the *ſmalt* is manufactured, is generally found a regulus of a whitiſh colour, inclining to red, which is extremely brittle. It is melted afreſh, and when cold it ſeparates into two parts; that at the bottom is the cobaltic regulus, which is employed to make more of the ſmalt by the proceſs already deſcribed: and the other at the top is biſmuth: for thoſe two ſemi-metals are found very often mixed in the natural ores.

But to aſſay ores of cobalt in ſmall quantities, by the dry way, it is enough to free them carefully from their matrix, and from all other heterogeneous matters: after which they are pounded, ſifted, and waſhed: their ſulphur is ſeparated by roaſting: and laſtly they are to be melted with three parts of *black flux*, in a lined and covered crucible, on a ſmith's forge. The beſt of theſe ores afford from 60 to 80 *per cent* of *regulus*; and the worſt under 25 *per cent*.

To aſſay the tinging power of cobaltic ores, the roaſted ore is to be melted in a crucible with 3 times its weight of *pot-aſh*, and 5 times of pounded glaſs, or prepared flint.

The

ing cobalt-glaſs, or zaffre, in any part of the world, where the abovementioned ingredients can be had.

The word Cobalt in Germany, and eſpecially at the mineral works in Saxony, is applied to the damps, the arſenic, its vapours, and their effects on man; which has induced the vulgar alſo to apply it to ſome pretended evil ſpirit, which is ſaid to dwell in the mines. But time will aboliſh theſe ſuperſtitions, which have their origin in ignorance.

SECT. 389. (254.)

1. Nickel. *Niccolum.*

Its general properties [*a*].

This ſemi-metal was firſt deſcribed by its diſcoverer Mr. Cronſtedt in the Acts of the

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The *pot-aſh* is to be put in firſt, then the *glaſs* or *flint*, and over all the *ore*.

If any biſmuth be contained in the cobalt ore, it will not mix with the regulus of cobalt, unleſs nickel be alſo contained in it, but will ſimply adhere to it; and may be ſeparated by the hammer, or by fuſion; for the biſmuth melts much more eaſily than cobalt.

When cobalt is united by means of nickel to biſmuth, the compound is called *Speiſs*. This is the name given alſo to a compound of *cobalt*, *nickel*, *biſmuth*, *ſulphur*, and *arſenic*. The Editor from *Kirwan*, p. 340 and *Lewis*, &c.

[*a*] 1. Nickel is a reddiſh-white ſemi-metal of great hardneſs, ſo that it can ſcarce be filed.

2. Its texture is equable, or uniform; and

3. It varies in its ſpecific gravities, according to its purity; from 7421 to 9000; the pureſt being the heavieſt.

Royal Academy of Sciences at Stockholm, for the years 1751 and 1754, where it is ſaid to have the following qualities: That

1. It is of a white colour, which however inclines ſomewhat to red,
2. Of a ſolid texture, and ſhinining in its fracture.
3. Its ſpecific gravity to water is as 8,500 :: 1,000.
4. It is pretty fixt in the fire; but together with the ſulphur and arſenic, with which its ore abounds, it is ſo volatile, as to riſe in form of hairs and branches, if in the calcination it is left without being ſtirred.
5. It calcines to a green calx.
6. This calx is not very fuſible, but it however tinges glaſs of a tranſparent reddiſh brown, or hyacinth colour.
7. It diſſolves in aqua fortis, aqua regia, and the ſpirit of ſea-ſalt, but more difficultly in the vitriolic acid, tinging all theſe ſolutions

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4. When very pure, it is in ſome degree malleable; and

5. Is always magnetic; from whence it is deemed to retain iron, though this ſeems to be rather a property belonging as well to itſelf, becauſe it appears to increaſe with its depuration.

6. It gives a hyacinthine colour to glaſs, which ſhould be blue whilſt it contained ſome mixture of cobalt.

7. The fuſibility of the common regulus is nearly the ſame as that of copper.

8. But the pureſt regulus is much more difficultly melted, or calcined.

9. It calcines more difficultly than cobalt; and,

10. Its

lutions of a deep green colour. Its vitriol is of the ſame colour; but the colcothar of this vitriol, as well as the precipitates from the ſolutions, become by calcination of a light green colour.

8. Theſe precipitates are diſſolved by the ſpirit of ſal ammoniac, and the ſolution has a blue colour; but being evaporated, and the ſediment reduced, there is no copper, but a nickel regulus is produced.

9. It has a ſtrong attraction to ſulphur; ſo that when its calx is mixed with it, and put on a ſcorifying teſt under the muffel, it forms a compound with the ſulphur which reſembles the yellow ſteel-grained copper-ores, and is hard and ſhining on its convex ſurface.

10. It unites with all the metals, except quickſilver and ſilver. When the nickel regulus is melted with the latter, it only adheres to it, both the metals lying near one another on the ſame plane; but they

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10. Its calx, which is *green*, riſes in a tuberoſe fungous form; but if nickel is thoroughly purified from arſenic, its calces are of a brown colour.

11. It is difficultly ſoluble in the *vitriolic* or *marine* acid, but eaſily in the *nitrous*.

12. All theſe ſolutions, which are green, turn to blue by the addition of volatil alkali; but iron diſcovers no copper in them, as it does in every combination of *copper*, *ſulphur*, *iron*, *arſenic* and *cobalt*.

13. Hence nickel muſt be deemed a diſtinct ſemi-metal. Beſides, Bergman has ſhewn that *ſulphur*, *arſenic*, and *cobalt*, may be perfectly ſeparated from nickel, though perhaps *iron* cannot without the utmoſt difficulty.

they are eaſily ſeparated with a hammer.

11. Cobalt has the ſtrongeſt attraction to nickel, after that to iron, and then to arſenic. The two former cannot be ſeparated from one another but by their ſcorification, which is eaſily done, ſince

12. This ſemi-metal retains its phlogiſton a long time in the fire, and its calx is reduced by the help of a very ſmall portion of inflammable matter: it requires, however, a red heat before it can be brought into fuſion, and melts a little ſooner, or almoſt as ſoon as copper or gold, conſequently ſooner than iron.

SECT. 390. (Additional.)

Native Nickel.

This is mentioned by Mr. *Rinman* to have been lately found in a mine of cobalt in *Heſſe*;

It is very heavy, and of a liver colour, that is, dark red;

When pulverized and roaſted under a muffle, it forms green excreſcences; and ſmokes, but

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14. It is, however, very evident, that if nickel has itſelf the property of being *magnetic*, as it was aſſerted N° 5, the teſt of the load-ſtone will always indicate, as if it contained a mixture of iron.

It is very probable, therefore, that nickel itſelf may be *magnetic*; and this ſeems to be the real caſe, as the more it is purified from iron, it becomes *more*, inſtead of *leſs* magnetic; and even acquires, what iron does not, the properties of a true magnet. *The Editor from* Bergman *and* Kirwan.

its

its ſmoke has no particular ſmell: and no ſublimate, whether ſulphureous or arſenical, can be caught;

It is ſoluble in acids,

And the ſolution is green;

But a poliſhed iron plate diſcovers no copper.

SECT. 391. (255.)

Aerated Nickel.

The nickel is found.

A. In form of a calx, *Niccolum calciforme.*

Nickel ochre, *Ochra niccoli.*

1. Mixed with the calx of iron, *Ochra niccoli martialis.*

This is green, and is found in form of flowers on Kupfernickel. In Normarken in the province of Wermeland, this ochre was found without any viſible nickel mixed in the clay, which contained a great quantity of native ſilver. *Sect.* 266, *p.* 542.

SECT. 392. (256.)

Kupfer nickel [*b*].

B. Mineraliſed nickel. *Niccolum mineraliſatum.*

1. With

[*b*] This ore is of a reddiſh-yellow, bright colour. Its texture is either uniform, granular, or ſcaly. It is bright in its fracture.

It

1. With ſulphurated and arſenicated iron and cobalt, *Niccolum ferro & cobalto arſenicatis et ſulphuratis mineraliſatum. Cuprum nicolai ſeu niccoli. Kupfernickel* [c].

This is of a reddiſh yellow colour, and is found,

a. Of a flaggy texture, in Saxony.

b. Fine-grained, and

c. Scaly, in Loos cobalt mines in the province of Helſingeland; at which place it is of a lighter colour than the foreign ones. Theſe two are often, from their colour, confounded with the liver-coloured marcaſite. Sect. 153.

SECT. 393. (257.)

Vitriolated Nickel.

2. With the acid of vitriol, *Niccolum acido vitrioli mineraliſatum.*

This is of a beautiful green colour, and may be extracted out of the nickel ochre, (Sect. 391.) or efflorescence of the Kupfernickel. *See Sect.* 211.

Is very heavy; and

Is generally covered with a greeniſh efflorescence.

By calcination it loſes much of its ſulphur, and becomes green, forming fungous ramifications. *The Editor from* Kirw.

[c] Mr. Raſpe aſſured me, that to his certain knowledge, nickel was found mineralized with ſulphurated iron and copper, in a mine near Nelſton, in Cornwall. *The Editor.*

SECT.

SECT. 394. (258.)

OBSERVATIONS on NICKEL [d].

The cobalt, biſmuth, and nickel, are commonly found together in the ſame mines, from which circumſtance it happens, that, when the firſt, as the moſt uſeful of them all, is to be made into glaſs, the adherent nickel, according to its nature, unites with the ſulphur and arſenic, of which ſome portion remains after the calcination, and forms a compound with them. When theſe minerals (the ſulphur and arſenic) are in greater quantity than is wanted for the nickel, they likewiſe reduce ſome part of the calces of the cobalt and biſmuth; and in this caſe the nickel, as a medium, uniting the other two, otherwiſe not miſcible ſemi-metals, incorporates them into the ſame compound. From hence ariſes a difference in the contents of theſe different mixtures; and from this difference, people, who have not ſufficient experience, form to themſelves

[d] The ore of nickel muſt be ſubjected to roaſting, in order to obtain its regulus: and, during this operation, a great quantity of ſulphur and arſenic, greater or leſs, according to the quality of the ore, is expelled; ſo that it ſometimes loſes upwards of half its weight, but frequently not above 0,3. This ore, though long and compleatly calcined, does not always acquire the ſame colour: but in general becomes *greener*, in proportion as it is more rich. Sometimes, eſpecially if ſuffered to lie at reſt, its upper ſurface

ſelves falſe notions of the whole compound, and of each part contained in it. For which reaſon they chuſe rather to retain that definition of the Kupfernickel which has received its ſanction from the earlieſt authors, than to admit the concluſion to which Mr. Cronſtedt's experiments ſeem to lead.

For my own part, I have found myſelf obliged to follow the opinion of the latter, partly becauſe I am tired with thoſe common epithets given to unknown bodies; ſuch as, *wild*, *refractory*, *rapacious*, *arſenical*, *irreducible*, *metallic earth*, &c. which regard the effect alone and not its cauſe; and partly becauſe I have not, beſides the nickel, found any metal or metallic compoſition, which

1. Becomes green when calcined.

2. Yields a vitriol, whoſe colcothar alſo becomes green in the fire.

3. So eaſily unites with ſulphur, and forms with it a compound of ſuch a peculiar nature, as the nickel does in this circumſtance; and that

4. Does

face is covered with green vegetations, ſomewhat of the form of thin corals, which are hard and ſonorous.

Let a double or triple quantity of *black flux* be added to the roaſted powder, and the mixture well fuſed in a forge, in an open crucible, covered with common ſalt, according to the uſual method. The veſſel being broken, a metallic globule is found at the bottom, under the ſcoriæ, which are *brown* or *black*, or ſometimes even *blue*. The weight of the globule amounts to 0,1, or 0,2; or, at moſt, to 0,5 of the crude ore.

This, however, is far from being pure; for although the roaſting be ever ſo violent and long continued, yet a conſiderable quantity of *ſulphur*, and eſpecially *arſenic*, ſtill remain concealed

4. Does not unite with ſilver, but only adheres or ſticks cloſe to it, when they have been melted together.

The nickel not having yet been found free from cobalt and iron, is the reaſon why it was not diſcovered. This was the caſe alſo with the cobalt. Platina del pinto perhaps, in the ſame manner, might for a long time have been mixed in the gold, at certain places, where it is ſaid to be naturally paler than any where elſe in the world. But the exiſtence of ſuch things cannot any longer be denied, ſince the method is diſcovered to obtain them ſeparate, and free from heterogeneous ſubſtances. It would be the ſame thing indeed, as if in a country where ſilver is never found but in the potter's lead ore, any perſon ſhould deny

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cealed in the regulus, excluſive of the *cobalt* and a great proportion of *iron*, which laſt is generally ſo prevalent as to make the regulus *magnetic*, unleſs this ſemi-metal itſelf poſſeſſes this laſt quality; for it ſeems ſtronger in proportion as the regulus undergoes other further purifications.

Nine ounces of the ſame regulus of nickel, that had been eliquated by Mr. Cronſtedt, and kept in the Suabian collection of the Upſal Academy, whoſe ſpecific gravity was =7,410, were reduced to powder, and expoſed in ſeveral diſhes, for the ſpace of 6 hours, to an exceedingly vehement heat, under the dome of an aſſay furnace. By this the arſenic was firſt diſſipated with a fœtid ſmell: a ſulphureous odour was next perceived: afterwards a quantity of white ſmoke, was emitted without garlick ſmell, which probably aroſe from the ſublimation of the more dephlogiſticated arſenic: the ſurface ſwelled in heaps, and green vegetations ſprang out from all the ſurface, reſembling *moſs*, or the *fili-form lichen*. There remained at the bottom a powder of a ferrugineous aſh-colour, and 0,13 of the ſubſtance was diſſipated by this operation.

Half

deny the exiſtence of either of theſe metals, or inſiſt upon it, that one is produced from the other.

It is remarkable, that the precipitates of nickel give a blue colour to the ſpirit of ſal ammoniac, when they are diſſolved in it; without ſhewing any other marks of copper, which, however, could not be concealed, if there were any; for if a ſmall quantity of copper is melted with the nickel, and kept in a ſtrong fire with it, the copper ſoon ſeparates, and ſcorifies, tinging the glaſs firſt of a reddiſh brown opaque, and, the fire being further forced, it then makes it tranſparent and green as uſual.

There is no danger attending the encreaſing the number of the metals. Aſtrological influences

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Half an ounce of this powder or calx, being fuſed in a forge for 4 minutes together, with 3 times its weight of black-flux, yielded a regulus, the ſurface of which was reticulated, all the areolæ being hexangular, with exceeding ſlender ſtriæ, diverging from a tuberculated center; its weight was $=0,73$ of half an ounce; was obedient to the magnet; and when ſcorified with borax, left a blackiſh glaſs.

The roaſting was repeated ſix times, for many hours: and the arſenic was ſeparated by the addition of powdered charcoal; and the reduction being effected with equal parts of *white flux*, *lime*, and *borax*, a regulus was obtained, ſemi ductile, highly magnetic, and ſoluble in nitrous acid, which became of a green colour by the ſolution.

The regulus of nickel being mineraliſed a third time with ſulphur, and reduced by powder of charcoal, produced a regulus, whoſe ſpecific gravity was $=8,666$; it not only adhered ſtrongly to the magnet, but to any other piece of iron; nay, the ſmall pieces of it attracted one another, and it was ſo duc-

4. tile,

fluences are now in no repute among the learned, and we have already more metals than planets within our ſolar ſyſtem. It would perhaps be more uſeful to diſcover more of theſe metals, than idly to loſe our time in repeating the numberleſs experiments which have been made, in order to diſcover the conſtituent parts of the metals already known. In this perſuaſion, I have avoided mentioning any hypotheſes about the principles of the metals, the proceſſes of mercurification, and other things of the like nature, with which, to tell the truth, I have never troubled myſelf.

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tile, that a globule, whoſe diameter did not exceed *one line*, was reduced by hammering to a plate of upwards of 3 lines in diameter: it was of a *whitiſh colour*, mixed with a glittering kind of *red*. The ſcoria of this regulus were almoſt always of a *hyacinthine colour*.

The analyſis of nickel in the *moiſt way*, is as yet very imperfect. By ſolution in the nitrous acid it is freed from its ſulphur; and, by adding water to the ſolution, biſmuth, if any, may be precipitated, as may ſilver if contained in it by the marine acid.

To ſeparate cobalt from nickel, when the cobalt is in conſiderable quantity, a ſaturated ſolution of the roaſted ore of nickel is to be dropped into a liquid volatil alkali. The cobaltic part is inſtantly re-diſſolved, and aſſumes a garnet colour. When filtered, a grey powder remains on the filter, which is the nickel. The cobaltic part may be precipitated from the volatil alkali by any acid.

If the ore be fuſed with 3 times its weight of *liver of ſulphur*, the cobalt will be taken up, and may be ſeparated by lixiviation.

It is highly probable that nickel exiſts in ſome ſpecies of roof-ſlates, and in horn-ſtones, whoſe ſolution in ſpirit of nitre is of a *green* colour. *The Editor from* Kirwan *and* Bergman.

N. B.

N. B. *Various Authors of ſome note, among whom ſtand Meſſrs.* Pabſt, Monnet *and* Romedel 'Iſle *have aſſerted that* cobalt, nickel, *and* manganeſe, *are nothing elſe but either* modifications *of* iron, *or* compounds of other known ſubſtances. *But Meſſrs* Cronſtedt, Bergman, *and lately Mr.* Kirwan *at the end of his* Elements of Mineralogy, *have compleatly evinced the fallacy of their arguments, ſo that no unprejudiced perſon can entertain any farther doubt to the contrary.* The Editor.

SECT. 395. (113.)

Manganeſe. *Manganeſium* [*a*].

It's general properties.

The ores of this kind are in Swediſh called *Brunſten*, in Latin *Sydereæ*, or *Magneſiæ nigræ*, in

[*a*] This kind of ore, commonly called *Black*, or *Glaſsmakers Magneſia*, is ſcarcely any thing more than a calx of a new ſemi-metal. This was, for the firſt time, clearly deſcribed, and its properties admirably inveſtigated and explained by Mr. Scheele in the *Memoirs of Stockholm* for 1774. It was afterwards exhibited in its metallic form by Mr. Gahn; and its properties in that ſtate were deſcribed by Mr. Bergman, in the 2d vol. of his works. Since that time it has frequently been produced in its metallic form by Meſſ. *Morveau* and *Lapeirouſe* in France, and lately here by Meſſ. *Woulfe* and Dr. *Pearſon*, &c.

This

in order to diſtinguiſh them from the *Magneſia alba officinalis*, and in French *Manganeſe*, &c. They are by ſome lithographiſts entirely omitted, and by others ranked among the iron ores; but, as I am convinced both by my own experience, and by that of others, that they contain no greater quantity of metal than ſometimes two or three per cent. of iron, and ſometimes a little tin, I think that the remaining part, which muſt conſequently be conſidered as a kind of earth, deſerves a particular and ſeparate place in a Mineral Syſtem, at leaſt until a farther acquaintance with its nature may be obtained: and to this opinion I have been perſuaded by its following peculiar qualities:

1. Man-

This regulus is of a duſky white colour, with an uneven and irregular ſurface, ariſing from its imperfect fuſion. It is bright and ſhining in its fracture, but ſoon tarniſhes by expoſure to air; q. is harder than iron, leſs fuſible, and very little. Its ſpecific gravity is = 6,850.

When pulveriſed it is always magnetic, though large pieces are not ſo. If expoſed to the air, particularly in moiſt weather, it ſoon crumbles into a blackiſh-brown powder, which is ſomething heavier than the regulus.

It is ſoluble in acids, but moſt readily in the nitrous. Its ſolutions are moſtly colourleſs; but that in the nitrous acid is generally browniſh, from a ſlight taint of iron: and there is always a ſpungy reſiduum of the nature of plumbago, left undiſſolved. Theſe ſolutions afford a white precipitate with aerated acids, which precipitate when heated, and grow black.

This regulus is obtained by mixing the calx, or ore of manganeſe, with pitch, making it into a ball, and putting it into a crucible with powdered charcoal $\frac{1}{16}$ of an inch thick on the ſides, and $\frac{1}{4}$ of an inch at the bottom. Then filling

1. Manganeſe conſiſts of a ſubſtance, which gives a colour both to glaſſes, and to the ſolutions of ſalts, or, which is the ſame thing, both to dry and to liquid menſtrua; viz.

a. Borax, which has diſſolved manganeſe in the fire, becomes tranſparent, of a reddiſh brown, or hyacinth colour.

b. The microcoſmic ſalt becomes tranſparent with it, of a crimſon colour, and moulders in the air.

c. With the fixed alcali, in compoſitions of glaſs, it becomes violet; but if a great quantity of manganeſe is added, the glaſs is in thick lumps, and looks black.

d. When ſcorified with lead, the glaſs obtains a reddiſh-brown colour.

e. The lixivium of deflagrated manganeſe is of a deep red colour.

2. It

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the empty ſpace with powdered charcoal, covering the crucible with another inverted and luted on, and expoſing it to the ſtrongeſt heat of a forge for one hour or more.

A ſmall piece of the regulus, put into a dry bottle well corked, remained perfect for the ſpace of 6 months; but afterwards expoſed to the open air of a chamber for two days, it contracted a brownneſs on the ſurface, and became ſo friable, as to crumble between the fingers. The internal parts, however, retained an obſcure metallic ſplendor, which diſappeared in a few hours.

It melts readily with other metals, pure mercury only excepted. Copper united with a certain quantity of it, is extremely malleable; but upon the ſurface of this mixture, when poliſhed, ſcarce any traces of the red colour are to be ſeen. This mixture ſometimes, by age, produces a green efflorescence.

When

2. It deflagrates with nitre, which is a proof that it contains ſome phlogiſton.
3. When reckoned to be light, it weighs as much as an iron ore of the ſame texture.
4. When melted together with vitreous compoſitions, it ferments during the ſolution: but it ferments in a ſtill greater degree, when it is melted with the microcoſmic ſalt.
5. It does not excite any effervescence with the nitrous acid: aqua regia, however, extracts the colour out of the black manganeſe, and diſſolves likewiſe a great portion of it, which, by means of an alcali, is precipitated to a white powder.
6. Such colours as are communicated to glaſſes by manganeſe, are eaſily deſtroyed by the calx of arſenic or tin: they alſo vaniſh of themſelves in the fire.
7. It is commonly of a looſe texture, ſo as to colour the fingers like ſoot, tho' it is of a metallic appearance when broken.

SECT.

When Manganeſe is melted with ſalt-petre, the maſs, according to Dr. Brunnich, aſſumes a *green colour*.

Tin very eaſily unites with manganeſe; but zinc not without much difficulty, perhaps on account of its volatility and inflammable nature. White Arſenic adheres to it, and by means of phlogiſton reduces it to a metallic form.

A mixture of powdered manganeſe with marine acid, is capable of diſſolving gold, if thin plates of it be dipped in the mixture.

SECT. 396. (Additional.)

Native Manganeſe. Manganeſium Nativum.

The diſcovery of native regulus of manganeſe, was far from being expected by rational mineralogiſts; for, as Mr. Kirwan obſerves, of all the metallic ſubſtances, manganeſe is the more ready to loſe the proportion of the required phlogiſton, for its natural mineraliſation: and unleſs alloyed in native iron, there could be no hopes of ſeeing ſuch a natural production.

We find, however, an account of this diſcovery, given by Mr. de la Peyrouſe, in the *Journal de Phyſique*, for January 1786: by which

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Manganeſe, calcined by fire, yields a blackiſh calx; but if the ignition be continued for 12 days, it acquires a dark-green colour: ſometimes alſo, it produces a white or a red calx. The black calx retains a very ſmall portion of phlogiſton, but the white abounds with it ſo much, that it is ſoluble in acids.

All theſe various calces, in a common crucible, by means of a ſufficient degree of fire, run into a yelloviſh red glaſs, which is pellucid, unleſs too great a degree of thickneſs renders it impervious to the rays of light.

The black calx of this ſemi-metal, when mixed with other ſubſtances, attracts phlogiſton with peculiar energy, and exhibits ſeveral remarkable phænomena both by fire and ſolution: which may be ſeen in the Treatiſe of Bergman upon the *White Grey calx of Iron*. The Editor from the ſame *Author*, and from *Kirwan*.

which it is evident that the manganeſium does naturally exiſt in the bowels of the earth. The following are its remarkable properties.

1. Its external appearance, colour, and figure are the very ſame as thoſe of the artificial regulus of manganeſe.
2. It likewiſe ſoils the fingers when handled.
3. Its ſubſtance is quite pure, having no particles that are in the leaſt attracted by the magnet.
4. Its texture is lamellated, and the lamellæ ſeem to affect a kind of divergence among themſelves.
5. It has the very ſame metallic brilliancy, as the artificial manganeſium.
6. It has alſo a partial malleability: and, when repeatedly hammered,
7. It exhibits a kind of exfoliation, forming itſelf into very thin leaves.
8. Its opacity and denſity is ſo compleatly ſimilar to that of the artificial regulus, that was it not for the natural matrix in which it is imbedded, it could not be at all diſtinguiſhed from it.
9. This ore is not found in large maſſes, or in a ſolid continued body, but only in lumps, and unconnected clots, incloſed and intermixed with the powdery manganeſe ore.
10. Theſe lumps are ſomewhat flattened, or compreſſed in their figure, like the artificial ones, though they are of a larger ſize for the moſt part.
11. And this powdery manganeſian ore, in which the reguline lumps are inbedded, has an ar-

gentine hue, which ſeems to countenance the ſuſpicion of its having been acted upon, by the violent heat of ſome natural deflagration on the ſpot.

This new manganeſe ore was found among the iron mines of *Sem*, on the valley called *Viederſos*, in the county of *Foix*, near the Pyrenean mountains.

SECT. 397. (114.)

Native Calces of Manganeſe.

Manganeſe is found [*b*],

A. Looſe and friable, *Manganeſium friabile terreum.*

a. Black, ſeems to be weathered or decayed particles of the indurated kind, from England.

SECT.

[*b*] The aerial acid is the only mineralizer of Manganeſe in its dry ſtate; and, according to the different degrees of the phlogiſtication of this ſemi-metal, it forms calces of different colours and different properties. It is to be underſtood, that when manganeſe is as much phlogiſticated as it can be, without being in a reguline ſtate, it forms a *white* calx, which contains a large portion of *fixed air* (about 40 *per cent.*) which enables it to retain phlogiſton, becauſe the compound of acid and calx, attracts phlogiſton more ſtrongly, than either does ſingly. In proportion, therefore, to its dephlogiſtication,

SECT. 398. (115.)

White and Red Manganeſe.

B. Indurated, *Manganeſia indurata.*

1. Pure, in form of balls, whoſe texture conſiſts of concentric fibres, *Manganeſia pura ſphærica radiis concentratis.*

a. White [*c*], *Manganeſia alba ſtrictè ſic dicta*, is very ſcarce. I have ſeen a ſpecimen of this

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giſtication, and its union with other ſubſtances, its colour is either *blue*, *green*, *yellow*, *red*, *brown*, or *black*.

The *blue* is that which it acquires from the proportion of phlogiſton it is enabled to retain, by reaſon of its union with fixed alkalies. The *green* ariſes from a mixture of the *blue*, with the *yellow* calx of iron. *Yellow* always ariſes from the prevalence of the calx of iron. *Red* from a ſlight phlogiſtication of that calx: and *black*, from its thorough dephlogiſtication.

Yet, if the *black* calx be long roaſted, it becomes *green*, which is thought to ariſe from the expulſion of the *fixed air*, which leaves its phlogiſton with the manganeſe, and thus produces a *blue*, which, mixed with the *yellow* calx of iron, becomes of a *green* colour. The *brown* ariſes from a mixtureof the *red* and *black* calces. All this note was extracted from *Scheele's Diſſertation* on the ſubject, by *Kirwan*.

[*c*] This contains but a very ſmall proportion of iron. It was found by Mr. Rinman both in ſmall white cryſtals, and in round maſſes, on the cavities of quartz, and adhering to glanz-blend. It is rather leſs hard than lime ſtone.

It is of a ſparry texture, and

Scarcely magnetic, even after roaſting.

Is ſoluble with efflorescence in *nitrous acid*; and

this kind in a collection from an unknown place in Norway; and by examining a piece of it, I found that it differed from the common manganeſe, by giving to borax a deep red colour in the fire: this ſort acquires a reddiſh brown colour when it is calcined.

b. Red manganeſe [*d*] is ſaid to be found in Piedmont. This I have never ſeen; but

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Affords a colourleſs ſolution, from which with mild alkalis ſeparates a white precipitate; and this, when heated, preſently grows black; a ſure criterion of being a true manganeſe.

Mr. Lapeirouſe found this white ore in the form of a ſpongy efflorescence, vegetating on the ſurface of ſome iron-ores, particularly on *hæmatites*.

Mr. Rinman found it alſo in the form of calcareous ſpar, *of the colour of roſin*, and ſomewhat ſhining, covered over, in ſome places, with a ſooty powder; and in thin pieces tranſparent at the edges, but not hard enough to ſtrike fire.

Nitrous acid diſſolves it almoſt entirely; with mild alkalis the ſolution affords a white precipitate, which becomes black when heated.

It conſiſts of *manganeſe* bedded in zeolite. It melts *per ſe* with the blow pipe into a whitiſh grey porous ſlag; and, with the addition of calcined borax, gives a garnet colour to glaſs.

Many of the white ſparry iron ores may alſo be claſſed among the ores of manganeſe, as they contain more of it than of iron. *Kirwan.*

[*d*] Red manganeſe contain leſs *fixed air*, and is accompanied with more iron than the preceding ore: and alſo with calcareous or ponderous earth; or barytes, and ſilex.

It is found either looſe and ſemi-indurated in a matrix of calcareous ſpar; or on talky ſhiſtus; or on hæmatites, and other iron ores; or in heavy hard maſſes of lamellar, radiated, or equable texture; or cryſtallized in pyramids, rhomboids, or ſhort brittle needles. *The Editor from* Kirwan. *See the note* [*e*] *to the next Section.*

I have

I have been told by an ingenious gentleman, that this variety is free from iron, and gives rather a red than a violet colour to glaſs.

SECT. 399. (116.)

Black Manganeſe.

2. Mixed with a ſmall quantity of iron, *Manganeſia parum martialis.*

a. Black manganeſe, with a metallic brightneſs. This is the moſt common kind, and is employed at the glaſs-houſes, and by the potters [*e*].

It

[*e*] 1. There are ſeveral varieties of this ſtone in the mountains round Bath, called *Mendip-hills*, of which the Briſtol potters conſume great quantities. *Brunnich.*

2. The *black* ore of Manganeſe differs but little from the *brown* ones; and they are both found either cryſtallized in the ſame form as the *red-ores*, or in ſolid maſſes, ſome of which have a metallic appearance; others are dull, earthy, and mixed, or embodied in quartz, or in a looſe earthy form.

3. Their ſpecific gravity is about = 4,000.

Both, particularly the *brown* and the *red*, are ſoluble in ſome meaſure by digeſtion in *oil of vitriol:* the ſolution is at firſt reddiſh, but afterwards becomes colourleſs, unleſs they contain a large proportion of iron.

4. But neither the *Dephlogiſticated nitrous acid*, nor the concentrated *vitriolic acid*, act upon them, unleſs *ſugar*, *honey*, *gum*, or other ſimilar *ſubſtance* be added; for then the ſolution will be promoted and compleated. This proceeds, as Bergman remarks, from the exhauſted ſtate of the

calx,

It is found,

1. Solid, of a flaggy texture; *Manganeſia textura vitrea*, from Skidberget, in the pariſh of Lekſand, in the province of Dalarne.

2. Steel

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calx, which has not phlogiſton enough to be acted upon by the acid, unleſs theſe ſubſtances furniſh the calx therewith.

5. If this calx is boiled with a ſolution of ſugar in water, it is not ſupplied with phlogiſton; and on being ſeparated by lotion, remains inſoluble as before. But if an acid be alſo added, by the help of it, a tranſlation of the phlogiſton then takes place, and the calx by its means takes up as much phlogiſton as to be rendered ſoluble; nay, the phlogiſticated vitriolic acid, when poured upon this calx, ſoon loſes its ſmell, and diſſolves it readily without any aſſiſtance.

6. The ſolution, juſt now mentioned, either by the dephlogiſticated nitrous, or by the concentrated vitriolic acid, is colourleſs; and, with mild alkalis, affords a white precipitate of the ſame nature as that already mentioned, N° 3.

7. Theſe calces, the *black* and *brown*, contain more iron and leſs fixed air, than the *red* and *white* ones, already ſpoken of.

The Perigord ſtone, Lapis Petracorius.

8. To the laſt variety of black manganeſe belongs the true *Perigord ſtone*; which is of a dark grey colour, like the *baſaltes* or *trapp*. It may be ſcraped with a knife, but it is difficultly broken. Its ſtructure is amorphous, very compact, heavy, and as black as charcoal. It has a glittering appearance of a ſtriated kind, like the antimonial ore: and its particles are diſpoſed in the form of needles, croſſing one another without any aglutination, inſomuch that ſome are looſe in the ſame manner as iron filings when ſtuck to a loadſtone; upon the whole they reſemble the ſcoria from a black ſmith's furnace.

9. This ſubſtance, when calcined, becomes of a reddiſh brown colour, and harder; but is not magnetic. Its ſpecific

gravity

2. Steel grained, alſo from Skidberget.
3. Radiated, *Radiata*, alſo from Skidberget, and Tiveden, in the province of Oſtergottland.
4. Criſtalliſed.

a. In

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gravity is conſiderable. It does not melt *per ſe*; but with borax it affords an amethyſt-coloured glaſs. Nitrous acid ſcarcely acts on it, without the addition of ſugar. This ſtone ſeems alſo to contain argill, and ſome portion of iron.

10. It is found in Gaſcony and Dauphiny, provinces of France, and in ſome parts of England. The French potters and common enamelers employ this ſubſtance ſometimes in the glaſſy varniſh of their earthen wares, &c. *The Editor from* Kirwan *and* Bomare.

Blackwadd.

11. This ſubſtance is found in Derbyſhire, and is one of the moſt remarkable ores of manganeſe. It is of a dark brown colour, partly in powder, and partly indurated and brittle. If half a pound of it be dried before a fire, and afterwards ſuffered to cool for about one hour, and then 2 ounces of linſeed oil be gradually poured on it, mixing the whole looſely like barm with flour, little clots will be formed: and in ſomething more than half an hour, the whole will grow hot, and at laſt burſt into a flame. The temperature of the room where this experiment was repeated, was about 30 *deg.* of Fahrenheit; and the heat this ore was expoſed to while drying, might be about 130 *degr.*

12. According to Wedgwood's analyſis, 100 parts of *blackwad* contain 43 of manganeſe, as much of iron, 4,5 of lead, and near 5 of micaceous earth. *The Editor from* Kirwan.

Manganeſe in vegetables.

13. Manganeſe ſeems to be contained in the aſhes of moſt vegetables; and to it the blue and greeniſh colour of calcined vegetable alkali is owing. Theſe colours are generally attributed to the phlogiſton of the alkali; but if ſo, they ſhould

not

a. In form of coherent hemiſpheres, *Hemiſpheriis continuis*, from Skidberget in Lekland.

SECT. 400. (118.)

OBSERVATIONS on MANGANESE (*f*).

Though it may ſeem difficult to many, to diſtinguiſh the kinds of manganeſe by their appearance,

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not be found in fixed nitre, as the nitrous acid ſhould carry off, during its decompoſition, all the phlogiſton. Yet this alkali is always greeniſh, ſo that the colour ſeems to ariſe from the aſhes of the charcoal with which the nitre was decompoſed.

If 3 parts of the alkali of tartar, 1 of ſifted aſhes, and $\frac{1}{2}$ of nitre, be melted together, they form a dark green maſs, which being diſſolved in water, affords a beautiful green ſolution; and this being filtered, on the addition of a few drops of oil of vitriol, becomes *red*; and after a few days a brown powder is depoſited, which has the properties of manganeſe. The aſhes of ſerpyllum contain very little of it. Thoſe of trees contain moſt. *The Editor chiefly from* Bergman *and* Kirwan.

[*f*] For reducing almoſt all the metallic-ores, ſome kind of fluxes are to be employed according to their kinds and circumſtances: but manganeſe has no need of any flux at all, requiring only to be expoſed to a quick and very violent heat at once; and ſuch is its propenſity towards vitrification, that the regulus never can be reduced to a ſingle maſs, but it is generally formed into various ſmall lumps, diſperſed between the remaining calces, as Mr. de la Peyrouſe obſerves.

To analyſe the above-mentioned ores of manganeſe, they ſhould be firſt roaſted, to dephlogiſticate the calx of the ſemi-metal, and the iron, if any is there contained. They

are

appearance, or external marks; yet it is extremely eaſy to know them by experiments made in the fire, if attention is had to the above-mentioned phænomena (Sect. 595.). From hence it is not difficult to comprehend why manganeſe has hitherto been either omitted, or erroneouſly ranked in ſyſtems, viz. becauſe it has, like many other mineral bodies, been examined only by ſight, while the more troubleſome method of examining it in the fire, has been overlooked.

Some might perhaps imagine the manganeſe to be the reſidue of ſome metal, which cannot be reduced again into its metallic ſtate; but it ought to be remembered, that no metal can, by any means yet known, be brought to an abſolutely irreducible earth or calx, unleſs perhaps by the burning-glaſs: and therefore there is no reaſon to ſuſpect that nature affords ſuch a production. Ignorance and idleneſs have invented certain terms or expreſſions, to avoid

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are then to be treated with dephlogiſticated nitrous acid, in order to diſſolve the earths. The reſiduum ſhould then be treated with nitrous acid and ſugar, by which means a colourleſs ſolution of manganeſe will be obtained; which, being precipitated by aerated mineral alkali, will afford a precipitate, 100 *gr.* of which are equivalent to as many of the regulus of manganeſe.

Many ſpecies of iron contain alſo manganeſe: and to diſcover it, let the iron be diſſolved in an acid, and precipitated by the Pruſſian alkali; let the ſolution be poured off, and the precipitate digeſted in pure water. The Pruſſian manganeſe will be diſſolved, and the Pruſſian iron will remain undiſſolved.

Otherwiſe, if a ſmall piece of the ore be heated white in a crucible, and 5 times its weight of purified nitre be projected

on

avoid giving an account of thoſe ores or mineraliſations, which are not eaſy enough to be decompounded; for inſtance, *wild*, *rapacious*, *arſenical*, *volatile*, &c. and ſome iron ores in particular have been thus called; by which means it has happened, that œconomical reflections have often been added to natural and philoſophical deſcriptions: and thus others are deterred from examining many bodies, of which we have acquired, and ſtill retain falſe notions ariſing from this way of proceeding.

The manganeſe has by ſyſtematiſts been commonly ranked among ſuch iron ores; but the artificers who make uſe of it in the manufacture of glaſs do not look upon it as ſuch; nor can they by any means be perſuaded to uſe any of the pretended bodies akin to it, inſtead of the manganeſe itſelf, for experience prevails more with them than ſuppoſitions. The conſumption of manganeſe is but ſmall, and therefore it is not a very profitable article.

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on it, taking care that no coal or aſhes ſhould get into the crucible; when all is cold, the upper part of the crucible will be covered with a *greeniſh* or *bluiſh* cruſt, if the iron contains manganeſe. When the ſolution of the iron, in the marine acid, is of a *red* colour; this alſo denotes the preſence of manganeſe, though this colour ſoon changes to a *yellow*, by acquiring phlogiſton from the martial part.

Manganeſe is of great uſe in the manufactory of glaſs and cryſtal, to deprive them of their green colour, which they would otherwiſe retain. Potters alſo make a great uſe of it for the glaſs-varniſh of their earthen and porcelain ware. But modern chemiſts employ it for other intereſting purpoſes, ſuch as to dephlogiſticate various menſtrua for delicate proceſſes, &c. *The Editor from* Bergman *and* Kirwan.

SECT.

SECT. 401. (*part of* Sect. 154.)

Molybdena. *Molybdena*, Lat. *Blyertz. Waſſerbleij*, Sw. *Waſſerbley. Reiſſerbley*, Germ. *Molybdena*, French.

a. Lamellar and ſhining, of the ſame colour as the potters lead ore. *Molybdæna pura membranacea nitens* [*a*].

From.

[*a*] This ſubſtance reſembles the plumbago of Sect. 231, and has long been confounded with it, even by our Author; but,

1. Its laminæ are larger, brighter: and, when thin, ſlightly flexible. They are of an hexagonal figure.

2. It is of a lead colour, and does not ſtrike fire with hard ſteel.

Its ſpecific gravity is=4,569, according to Kirwan; and 4,7385, according to Briſſon.

4. When rubbed on white paper, it leaves traces of a dark brown or bluiſh colour, as the plumbago or black lead does; but they are rather of an argentine gloſs, by which circumſtance the Molybdena, according to Dr. d'Arcet, may be eaſily diſtinguiſhed from black lead, as the traces made by this laſt are of a darker hue, leſs brilliant, and of a deeper tinge.

5. In an open fire it is almoſt intirely volatil, and infuſible. Microcoſmic ſalt, or borax, ſcarcely affect it; but it is acted upon with much efferveſcence, by mineral alkali, and forms with it a reddiſh maſs, which ſmells of ſulphur.

6. It is affected by no acid but the nitrous and arſenical, both of which require the aſſiſtance of heat; the latter is converted into orpiment by it.

7. It conſiſts of an acid of peculiar nature (deſcribed in Sect. 162), united to ſulphur. A ſmall proportion of iron is commonly found in it, but this ſeems merely fortuitous:

From Biſpergs Klack in the province of Dalarne, Baſtnas-grufva at Riddarſhyttan in Weſtmanland, Altenburgh in Saxony.

The variety from Biſpergs Klack has been examined by Mr. Quiſt, and has, by its volatiliſing under the muffel, in form of a white fibrous

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100 parts of molybdena contain about 45 of this acid, and 55 of ſulphur.

8. It is decompoſed either by detonation with nitre, or by ſolution in nitrous acid; the latter method is the readieſt. For this purpoſe it is to be five times diſtilled, each time with four times its weight of ſpirit of nitre: a white calx at laſt remains, which is the molybdenous acid.

9. This acid is ſoluble in 570 times its weight of water in the temperature of 60; the ſolution reddens that of litmus, precipitates ſulphur from the ſolution of liver of ſulphur, &c. The ſpecific gravity of the dry acid is 3,460. 3 *Bergm.* p. 127.

10. This acid is precipitable from its ſolution in water by the *Pruſſian* alkali, and alſo by tincture of galls: the precipitate is reddiſh brown.

11. If this acid be diſtilled with three times its weight of ſulphur, it re-produces molybdena.

12. The ſolution of this acid in water unites to fixed alkalis, and forms cryſtallizable ſalts; as it alſo does, with calcareous earth, magneſia, and argil; theſe laſt combinations are difficultly ſoluble; it acts alſo on the baſe metals, and with them aſſumes a bluiſh colour.

13. This ſolution precipitates ſilver, mercury, or lead, from the nitrous acid, and lead from the marine, but not mercury.

24. It alſo precipitates barytes from the nitrous and marine acids, but no other earth. Molybdenous baroſelenite is ſoluble in cold water.

15. This acid is itſelf ſoluble in the vitriolic acid by the aſſiſtance of heat; and the ſolution is blue when cold, though colourleſs while hot; it is alſo ſoluble in the marine acid, but not in the nitrous.

16. Molybdenous

fibrous ſublimate, induced that gentleman to examine the black lead more particularly. He has publiſhed ſome very remarkable experiments on it in the Tranſactions of the Academy of Sciences at Stockholm, for the year 1754.

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16. Molybdenous tartar and ammoniac precipitate all metals from their ſolutions by a double affinity. Gold, ſublimate corroſive, zinc, and manganeſe, are precipitated *white*; iron, or tin, from the marine acid, *brown*; cobalt, *red*; copper, *blue*; alum and calcareous earth *white*. *Scheele Mem. Stock.* 1778.

17. This acid has been lately reduced by Mr. *Hielm*, but the properties of the regulus thus obtained are not yet publiſhed.

81. Mr. Pelletier obtained alſo the regulus of molybdena, by mixing its powder with oil into a paſte, and expoſing it with powdered charcoal in a crucible, to a very violent fire for two hours. By this proceſs he obtained various globules or beads of regulus, which he found to have the following properties: 1. It may be deprived of its phlogiſton by calcination, and reduced to a calx more or leſs white: 2. It detonates with nitre on the fire, and a combination of the calx with the alkali remains behind: 3. with nitrous acid, it becomes calcined into a white calx: 4. in the dry way treated with alkalis, it produces inflammable air: 5. it unites with metallic ſubſtances, forming as many alloys: 6. and treated with ſulphur, regenerates mineralized molybdena.

19. This ſemi-metal being urged by a ſtrong fire for an hour, produces a kind of ſilvery flowers, like thoſe of Antimony,

20. It is ſaid that molybdena is ſoluble in melted ſulphur, which ſeems highly probable, as ſulphur is one of its component parts.

Molybdena is found ſometimes along with Tin ores, and Iron ores, that are attracted by the magnet, among copperiſh pyrites; and alſo with Wolfram, not only in Saxony, Iceland, France, but in Spain, Sweden, &c. *The Editor, from* Kirwan, Scheele, Pelletier, &c.

SECT. 402. (117.)

Wolfram. Wolfranum, Spuma Lupi, *Lat.*

This mineral has the appearance of Manganeſe, blended with a ſmall quantity of iron and tin, *Manganeſia, parvâ cum portione martis et jovis mixta: Spuma Lupi,* or *Wolfram* [*b*].

1. With

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b. 1. This mineral, which the Germans have called *Wolfram*, or Wolfrath, a name tranſlated into Latin *Spuma Lupi*, or rather *Lupus Jovis*, has been met with hitherto only in mines of tin; for, though many authors would make it more common, it is an error owing to their confounding ſome gloſſy iron-ores with the true Wolfram, as appears by the ſpecimens which are frequently found in Cabinets under this name. It has been on account of the bad effects produced by this mineral in the ſmelting of tin-ores, from which it is very difficult to ſeparate it by waſhing, becauſe of its great ſpecific weight, that the names of *Spuma Lupi*, *Lupus Jovis*, and *Wolfram*, have been given to it, by the miners and ſmelters.

2. This is really a metallic ore, and contains the very ſemi-metal lately diſcovered in the *Tungſtein* of Sect. 27; both being mineralized, or rather formed by the ſame *Tungſtenic* acid, already deſcribed in Sect. 163. And having treated already in theſe two Sections of both, it only remains now to ſpeak of the *Wolfram*.

3. This metallic ore, which is generally found in tin mines; as before ſaid, is of a black or brown ſhining colour, of a radiated or foliated texture, of a moderate hardneſs, and ſometimes ſo brittle as to be eaſily broken between the fingers; but it is very weighty, ſince its ſpecific gravity is = 7,119.

4. When

1. With coarſe fibres.

a. Of an iron colour, from Altenberg in Saxony. This gives to the glaſs compoſitions,

4. When ſcratched it ſhews a red trace, and this diſtinguiſhes it from the Tungſtein of Sect. 27. which is a variety of the ore of the ſame ſemi-metal.

5. It is found in ſcattered maſſes, cryſtallized into hexaëdral flat priſms, coming to a point, with 4 ſides, and theſe points terminated obliquely.

6. Internally it is ſhining, with the luſtre almoſt of a metal.

7. When it is broken, its texture appears leafy; and the leaves are flat, but ſomewhat confuſed;

8. On ſome ſides they are unequal, and very ſeldom ſtriated.

9. It is always opake; and when ſcraped, it yields a powder of a dark reddiſh grey.

10. The Wolfram will not melt by itſelf with the blow-pipe: the angles being only rounded; but

11. Internally it preſerves its ſtructure and colour without change.

12. With microſcomic ſalt it fuſes with effervescence; and forms a glaſs of a pale red in the exterior flame, and much darker in the interior.

13. With borax it likewiſe effervesces, and forms by the interior flame a glaſs of a greeniſh yellow, which by the exterior turns reddiſh.

14. Being expoſed in a crucible to a ſtrong fire for one hour, it ſwelled, became ſpongy, and of a browniſh colour; entered into a ſemi-vitrification; and was attracted by the magnet.

15. Equal parts of nitre and wolfram being put in a red-hot crucible, they detonated, or rather boiled up with a blue flame round the edges; and a nitrous vapour aroſe: the matter, when cold, on being put into water, partly diſſolved: and a few drops of acid produced a white precipitation.

16. Pounded Wolfram, digeſted in a ſand-heat with a ſufficient quantity of marine acid, to the depth of the thickneſs

tions, and alſo to borax and the microcoſmic ſalt, an opaque whitiſh yellow colour, which at laſt vaniſhes.

ON

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of a finger above the matter, after one hour's boiling, the powder turned yellow; which is the ſame phenomenon as happens with the tungſtenic acid of Sect. 163.

17. It appears by the chemical analyſis of Wolfram made by Meſſ. John and Fauſt de Luyart, that its contents conſiſt of 22 parts of manganeſe in the ſtate of black calx; 13,5 of iron, 65 of a yellow wolfranic calx, and of quartz and tin.

18. A good quantity of this yellow calx being collected, it was obſerved that it was entirely inſipid, and that its ſpecific gravity was=6,120. It effervesces with microcoſmic ſalt: produces a tranſparent blue colour without any ſhade of red; and effervesces alſo with borax, and with mineral alkali. This ſame matter does not diſſolve in water; but when triturated with it, forms a kind of emulſion; to which the acetous acid gives a blue colour, but does not diſſolve it. This matter, however, diſſolves compleatly in cauſtic vegetable alkali, both by the *dry* and *moiſt way*; and the liquor acquires a great bitterneſs. By pouring on it ſome nitrous acid a precipitate enſues, which leaves on the filtre a white ſalt; and this being well edulcorated, has a taſte at firſt *ſweet*, afterwards *ſharp* and *bitter*, producing a very diſagreeable ſenſation on the throat. It is in fact a true acid combined with a portion of the alkali and precipitating acid.

19. This acid melts, if alone, by the flame urged with the blow-pipe.

20. This white ſalt is a true metallic triple ſalt, as appears by putting 100 *gr.* in a crucible with powdered charcoal; for after one hour and a half of a ſtrong fire, when cooled a button was found, which fell to powder between the fingers. Its colour was brown; and, on examining it with a magnifier, there was a congeries of metallic globules, of the bigneſs of pin's heads; which, when broken, exhibit the metallic appearance, of a ſteel colour in the fracture: and their ſpecific gravity was=17,600.

21. Theſe

On the Siderite.

The ſuppoſed new metal, named Siderite, *was firſt diſcovered by Mr. Meyer of Stetin. But Profeſſor Bergman and Mr. Kirwan (beſides various other chymical and mineralogical philoſophers) ſoon applied themſelves to inveſtigate the properties of this ſubſtance, till at laſt the ſame diſcoverer, Mr. Meyer, happily aſcertained by the ſynthetic method, that it was nothing elſe but a natural combination of the phoſphoric acid with iron; and publiſhed an account of his miſtake. This very combination, however, is an important diſcovery in nature, and the knowledge acquired by the inveſtigation of its properties, is a very valuable acquiſition to the common ſtock of modern diſcoveries. The words of the ſame ingenious philoſopher, the inventor, may*

21. Theſe metallic globules, melted with other metals, gold and platina excepted, afford ductile alloys with ſilver or copper; and hard ones with caſt iron, tin, antimony, biſmuth, and manganeſe.

22. It is therefore evident that this is a new metal before unknown, as it is evinced, 1. by its ſpecific gravity, equal to 17,600: 2. by the tinges it gives to different glaſſes: 3. by its great difficulty to fuſe, which is greater than that of manganeſe: 4. by the yellow colour of its calx: 5. its alloys with other metals: 6. its inſolubility, at leaſt by a direct method, with mineral acids: 7. its eaſy ſolution in alkalis: 8. the emulſion it gives with water: 9. and by the blue colour it gives to acetous acid. All theſe properties are ſufficient to demonſtrate that this Wolfranic ſubſtance is a metal *ſui generis*, diſtinct from all others. *The Editor, chiefly from the* Chemical analyſis of *Wolfran*, by *Meſſ. de Luyart.*

ſerve to ſhew this: what a plentiful ſource, ſays he, of *phoſphoric acid* would be opened to us, if it were but eaſy to ſeparate! The cloſe combination of this acid with iron, is alſo very remarkable.

Mr. Klaproth of Berlin, by a remarkable coincidence, came to the very ſame concluſion, without any communication with Mr. Mayer. He did not attempt to eſtabliſh his opinion by analytical experiments, as he conceived that it would be difficult to ſeparate the iron and the acid, either by phlogiſton or any other way. He found, however, the artificial compound of phoſphoric acid *and* iron, *to agree in its properties with the* calx ſideri alba, *obtained by Bergman and Mayer from the* cold-ſhort iron, *which is extracted from the* ſwampy *or* marſhy *ores, deſcribed at p.* 732. *The* native Pruſſian blue iron ore, *of Sect.* 341, *which is extracted from ſimilar ores, contains alſo the ſame combination of the ſiderite in a much larger portion.* The Editor from *Bergman*, and his *Engliſh Tranſlator.*

On the Saturnite.

Mr. Kirwan gave this name to a ſuppoſed new metallic ſubſtance, announced by Mr. Monnet, as found in the lead-founderies of Poullaouen *in Brittany, where it is ſeparated from the lead ore, during its torrefaction. It is deſcribed as reſembling lead in its colour, ſpecific gravity, ſolubility in acids, and other ſimilar qualities to thoſe of lead: excepting only that it is more fuſible,*

fusible, very brittle, easily scorified and volatilized; and not miscible with lead, when in fusion.

But Messf. Hassenfratz and Giroud have demonstrated, both by the analytical and synthetical methods, that this very metallic substance, the saturnite, *which was formerly neglected, but which is now kept for useful purposes at the said founderies of Poullaouen, is nothing but a simple mixture or alloy of various metals, which separates of itself, on account of its greater fusibility, whilst the lead-ores are roasting in the furnace.*

The following table is extracted from Journal de Physique, *for January* 1786, *p.* 63, *and shews the names and respective quantity of each metal that is generally combined in the* saturnite. *It is easily conceived, that they must often vary, according to the different ores that happen to be roasted at every time in the furnace.*

	lb.	oz.	gros.	grains.
Lead	40	13	6	6
Copper	31	4	0	0
Iron	4	1	2	0
Silver	0	2	1	66
Sulphur	23	10	6	0
The Sum	100	0	0	0

There will be no difficulty in reducing these French *weights into the* English, *by taking notice of the following circumstances:*

1st, that the French pound, or livre *of two* marks, *contains* grains. 9216

and is divided into 16 *ounces, each containing* grains. 576

or into 128 *drams (or* gros*), each weighing* 72

2*dly, that the proportion of the* French *pound weight to the* Engliſh, *called* avoirdupoids, *is*, according to Pauĉton's Metrologie, as 10000 : 0,9254.

3*dly, that in conſequence of this proportion, this laſt (the Engliſh pound,* averdupois) *is equal to* 8537, 7024 *French grains*

4*thly, But as the ſame Engliſh pound contains only* 7000 Engliſh grains; *it follows, that theſe Engliſh grains are greater than the French ones, in the proportion of* 85 (*or* 85,38) *to* 70; *ſo that* 85 *French grains are equal to* 70 *Engliſh ones.* The Editor.

It appears, however, by the *Journal de Phyſique* for March following, p. 169. that M. Monnet does not admit that the Saturnite, analyſed by Meſſ. Haſſenfratz and Giroûd, is of the ſame kind as that diſcovered by him; and he adds, that on his having recourſe again to the Mines of Poullaonen, in 1783, his new metal was not to be found. We can only add, that this is a moſt ſingular diſappointment!

APPENDIX,

ROYAL ASIATIC SOCIETY

APPENDIX.

SECT. 403. (259.)

INTRODUCTION.

I Have already in the preface mentioned the reaſons why the Saxa and Foſſils commonly called *Petrefactions* cannot be ranked in a Mineral Syſtem: and I am perſuaded, that the ſame reaſon which has prevailed on me, will likewiſe after mature conſideration be approved by others. In the mean time, ſince theſe bodies, eſpecially the latter, occupy ſo conſiderable a place in moſt Mineral Collections, and the former muſt neceſſarily be taken notice of, by the miners, in the obſervations they make in the ſubterranean geography, I would not entirely omit them here; but have endeavored to put them in ſuch an order as may anſwer that purpoſe, for which Miners and Mineralogiſts pay any regard to them.

SECT.

SECT. 404. (260.)

The FIRST ORDER.

SAXA. *PETRÆ.*

I divide theſe into two kinds.

1. Compound Saxa, *Saxa compoſita,*

Are ſtones whoſe particles, conſiſting of different ſubſtances, are ſo exactly fitted and joined together, that no empty ſpace, or even cement, can be perceived between them; which ſeems to indicate, that ſome, if not all, of theſe ſubſtances have been ſoft at the inſtant of their union.

2. Conglutinated ſtones, *Saxa conglutinata,*

Are ſuch ſtones whoſe particles have been united by ſome cementitious ſubſtance, which, however, is ſeldom perceivable, and which often has not been ſufficient to fill every ſpace between the particles. In this caſe the particles ſeem to have been hard, worn off, and in looſe, ſingle, unfigured pieces, before they were united.

SECT. 405. (261.)

1. Compound Saxa, *Saxa Compoſita.*

A. Ophites. Scaly limeſtone with kernels or bits of ſerpentine ſtone in it, *Saxum*

compoſitum particulis calcareis et argillaceis.

1. *Kolmord marble.* It is white and green.
2. *Serpentino antico*, is white, with round pieces of black ſteatites in it. This muſt not be confounded with the *Serpentino verde antico*, of Sect. 409.
3. The *Haraldſio marble.* White, with quadrangular pieces of black ſteatites.
4. The *Marmor Pozzevera di Genova.* Dark green marble, with white veins.

This kind receives its fine poliſh and appearance from the ſerpentine ſtone.

SECT. 406. (263.)

B. Stellſten or Geſtellſtein. *Saxum compoſitum particulis quartzoſis & micaceis.* Granitello.

1. Of diſtinct particles, *Particulis diſtinctis.*

This is found at Garpenberg in the province of Dalarne. It is likewiſe met with in the other mineral mountains of Sweden. In ſome of theſe the quartzoſe particles predominate, and in others, the micaceous. In the laſt caſe it is commonly ſlaty, and eaſy to ſplit.

2. Of particles which are wrapt up one in another, *Particulis quartzoſis micâ convolutis.*
   - *a.* Whitiſh grey, from Morthernberget in Norberke in Dalarne.
   - *b.* Greeniſh, at Salberg in Weſtmanland.
   - *c.* Reddiſh, from the pariſh of Malung in Dalarne.

Both

Both theſe kinds of Stellſten are, for their reſiſtance to the fire, employed in building furnaces; but the latter is the beſt, becauſe it ſeems at the ſame time to contain a little of a refractory clayiſh ſubſtance. The reddiſh from Malung however cracks very ſoon, if the flat ſide of the ſtratum, inſtead of the extremity, is turned towards the fire. It is alſo of great uſe in mills, if the other or fellow-ſtone is made of the mill-ſtone from Arſunde, which is a Saxum of the conglutinated kind, or a coarſe ſand-ſtone. It is fortunate for œconomical purpoſes, that the plates of theſe ſtones are ſo thick, although thereby they are not ſo eaſily ſplit.

SECT. 407. (263.)

C. *Norrka* and *Murkſten* of the Swedes, *Saxum Compoſitum, micâ, quartzo, et granato.*

1. With diſtinct garnets or ſhirls, *granatis diſtinctis cryſtalliſatis.*
   - *a.* Light grey, from Selbo in Norway.
   - *b.* Dark grey, with very ſmall garnets, from Quarnberget in the pariſh of Soderli in the province of Jemteland.
   - *c.* Dark grey, with priſmatical, radiated, or fibrous cockle or ſhirl, from the village of Handol, in the pariſh of Are in Jemteland.
2. With kernels of garnet ſtone, *Particulis granatis indeterminatis.*

a. Of pale red garnet ſtone, from Stollberget in Norberke in Dalarne.

The firſt of this kind, whoſe ſlaty ſtrata makes it commonly eaſy to be ſplit, is employed for mill-ſtones, which may without difficulty be accompliſhed, if ſand is firſt ground with them, becauſe the ſand wears away the micaceous particles at the ſurface, and leaves the garnets prominent, which renders the ſtone fitter for grinding the corn.

SECT. 408. (264.)

D. The Whetſtone, *Cos. Saxum compoſitum micâ, quartzo, et forſan argillâ martiali in nonnullis ſpeciebus.*

1. Of coarſe particles, *Particulis diſtinctis.*
   a. White, from Wanga in the province of Skone.
   b. Light grey, from Tellemarken in Norway.
2. Of fine particles, *Particulis minoribus.*
   a. Liver brown colour, from Selbo in Norway.
   b. Blackiſh grey, from Lerwik in Hellefors in Weſtmanland, and from Cologne in Germany.
   c. Light grey, from Hellefors in Weſtmanland.
   d. Black. The table ſlate, or that kind uſed for large tables, and for ſchool-ſlates.

The

The naked eye, and the magnifying glaſs much better, diſcovers the micaceous particles in this kind to be as it were twiſted in one another. Some clay ſeems likewiſe to enter into the compoſition. However, it cannot yet be certainly aſſerted, that it is real mica which has that appearance in this kind.

3. Of very minute and cloſely combined particles, *Cos particulis conſtans impalpabilibus durus.* The Turky ſtone [*a*].

This is of an olive colour, and ſeems to be the fineſt mixture of the firſt ſpecies of this genus. It is found in looſe ſtones at Biorkſkoginas in the pariſh of Hellefors in Weſtmanland, though not perfectly free from croſs veins of quartz, which always are in the ſurface of the rock, and ſpoil the whetſtones. It is alſo ſaid to be found in Tellemarken in Norway. The beſt ſort of this comes from the Levant and is pretty dear. The whet-ſtone kinds, when they ſplit eaſily, and in thin plates, are very fit to cover houſes with, though moſt of them are not of ſuch qualities.

N. B. *The Sect.* 265. *in which the Author deſcribed the* Telgſtein, *has been placed among the* Magneſian earths, *in Sect.* 61. *p.* 104. *to which it properly belongs.* The Editor.

[*a*] *See Sect.* 126, *where this ſtone is fully deſcribed.* The Editor.

SECT.

SECT. 409. (266.)

F. Pophyry, *Porphyrites.* Italorum *Porfido. Saxum compoſitum jaſpide et feltſpato, interdum micâ et baſalte* [*b*].

a. Its colour is green, with a light green feltſpar, *Serpentino verde antico.* It is ſaid to have been brought from Egypt to Rome, from which latter place the ſpecimens of it now come.

b. Deep red, with white feltſpar, from Italy, and Egern in Norway.

c. Black, with white and red feltſpar, from Klitten, in the pariſh of Elfdalen in Dalarne.

d. Reddiſh brown, with light-red and white feltſpar, from Hykieberget in Elfdalen, and Guſtavſtrom, in the pariſh of Goſborn in the province of Wermeland.

e. Dark grey, with white grains of feltſpar alſo from Gulavsſtrom.

Many varieties of this kind, in regard to colour, are found in form of nodules or looſe ſtones in Sweden; but I have only mentioned the hardeſt and fineſt of thoſe which are found in the rocks; becauſe, beſides theſe, there are coarſe porphyries found, which ſcarce admit of any poliſh. The dark red porphyry has been moſt employed for ornaments, in building, &c. yet it is not the only one known by the name of *Porfido*, the Italians applying the ſame name alſo to the black kind.

SECT.

[*b*] Under the name of *Porphyry*, or *Porfido* of the Italians, both Mr. de Sauſſure and Mr. Kirwan reckon thoſe ſtones, which contain either *feltſpar*, *quartz*, *ſhoerl*, *mica*, with other ſpecies of ſtone of a cryſtalline form, in a *ſiliceous*, or even *calcareous*

[*] SECT. 410. (267.)

G. The *Trapp* of the Swedes. Saxum compositum jaſpide martiali molli, ſeu argillâ martiali induratâ. . . . [*d*].

This kind of ſtone ſometimes conſtitutes or forms whole mountains; as, for example, the

calcareous ground. Mr. Ferber, in his 16th letter from Italy, deſcribes 20 varieties of Porfido, under four ſpecies. But in general it is conſidered according to the colour of its ground, *viz.* either *red*, *purple*, *grey*, *green*, or *black*. When the ground is of jaſper (Sect. 107. and following), the porfido is very hard. The *red* commonly contains *felt-ſpar*, in ſmall white dots or ſpecks, and often together with theſe, black ſpots of ſhoerl. The *green* is either a jaſper or ſhoerl, with ſpots of quartz. This is often magnetic. Sometimes a porphyry of one colour contains a fragment of a porphyry of another colour. Thoſe that have *chert* for their ground, are fuſible *per ſe*. The Calcareous Porphyry conſiſts of *quartz*, *felt-ſpar*, and *mica*, in ſeparate grains, united by a calcareous cement. And finally, the Micaceous Porphyry, conſiſts of a greeniſh-grey micaceous ground, in which red felt-ſpar and greeniſh ſoap-rock are inſerted. *The Editor.*

[*d*] This ſtone is ſo called, on account of its moſt common external appearance or figure; it being formed into ſteps like a ſtair, called *trapp* in Swediſh. Bergman found that this ſtone has the ſame component parts as the baſaltes; and there cannot be the leaſt doubt of both being the very ſame ſubſtance.

It is generally called *Saxum Danemorenſe*. According to Kirwan, it is compoſed of *Siliceous earth*, mixed with 0,3 of its weight of *argill*, 0,17 of *mild calcareous earth*, 0,04 of magneſia, and 0,5 of *iron*. Bergman, however, had expreſſed the ſame contents of this ſtone in an eaſier way, at p. 213 of his Treatiſe *de Productis Vulcanicis* of Upſal's edition, 1783; ſaying that the trapp has the very component parts, and in the ſame proportion, as the *baſaltes*, viz. in 100 parts, 52 are of *ſiliceous* earth; 15 of *argillaceous*; 8 of

aereed.

the mountain called Hunneberg, in the province of Weſtergottland, and at Drammen in Norway. But it is oftener found in the form of veins in mountains of another kind, running commonly in a ſerpentine manner, contrary or acroſs to the direction of the rock itſelf. It is not homogeneous, as may be plainly ſeen at thoſe places where it is not preſſed cloſe together; but when it is preſſed cloſe, it ſeems to be perfectly free from heterogeneous ſubſtances.

When this kind is very coarſe, it is interſperſed with feltſpar; but it is not known if the finer ſorts likewiſe contain any of it. Beſides this, there are alſo ſome fibrous particles in it, and ſomething that reſembles a calcareous ſpar. This however does not ferment with acids; but melts as eaſily as the ſtone itſelf, which becomes a black ſolid glaſs in the fire. By calcination it becomes red, and yields in aſſays 12 or more per cent. of iron. No other ſort of ore is to be found in it, unleſs now and then ſomewhat merely ſuperficial lies in its fiſſures; for this ſtone is commonly, even to a great depth in the rock, cracked in acute angles, or in form of large rhomboidal dice.

It

aerated calcareous; and 25 of *iron*, if analyſed by the *phlogiſticated* alkali; if otherwiſe, by the common method, only 10 parts of the iron could be determined.

But although this great man found the ſame component parts, and the very ſimilar appearances, both in the baſaltes and the trap, he did not admit the laſt to be a volcanic production. I leave to the reader to decide upon the arguments on which this great man has grounded his doubts: yet ſince ſmall pieces of lavas, and other volcanic productions, are really

It is employed at the glaſs-houſes, and added to the compoſition of which bottles are made. By the Germans it is called *Schwach* or *Schwartſtein*; at the Swediſh glaſs-works, *Trappſkiol*, *Tegelſkoil*, or *Swartskoil*; and at Jarlſberg in Norway, *Blabeſt*. In the air it decays a little, leaving a powder of a brown colour; it cracks commonly in the fire, and becomes reddiſh brown if made red hot. It is found

1. Of coarſe chaffy particles, *Particulis majoribus aceroſis*.
   a. Dark grey, from the top of Kinnekulle in the province of Weſtergottland.
   b. Black, from Stallberget at Oſterſilfverberget in the province of Dalarne.
2. Coarſe-grained, *Particulis majoribus granulatis*.
   a. Dark grey, from the uppermoſt ſtratum at Hunneberg in Weſtergottland.
   b. Reddiſh, from Bragnas in Norway.
   c. Deep brown, from Gello in Norway.
3. Of fine imperceptible particles, *Particulis impalpabilibus*.
   a. Black. The touchſtone, *Lapis Lydius*, from Salberg mine, Helleſors Weſterſilverberget,

found, where no appearance of fuſed matters can be diſcovered, they muſt be attributed to the great convulſions and revolutions of this globe, already hinted at in the note to p. 486; which have overthrown, and even tranſported to very diſtant places of the earth, where no other volcanic traces can be found, very large tracts and mountains of baſaltes, trapp, and lavas, after they have been formed by anterior eruptions of volcanic fires, &c.

berget, and Norberg in Weſtmanland, and Oſterſilverget in Dalarne, &c. [*b*]

b. Blueiſh, from Oſterſilfverberget.

c. Grey, from Dalwik in the pariſh of Sorberke in Dalarne.

d. Reddiſh, from Dalſtugun in the pariſh of Rettwik in Dalarne.

The texture of the trapp is either coarſe, rough, and diſtinct, in its aggregate parts, or elſe they are fine and indiſcernible. This laſt ſort is often rediſh, always opake, and moulders by expoſure to the air. Some of its ſpecimens give fire with ſteel very difficultly, though it is always very compact. It looks ſometimes as ſprinkled over with a few minute ſhining particles.

Its ſpecific gravity is = 3,000. It is generally inveſted with a ferrugineous cruſt; and is often cryſtalliſed in opake triangular, or polyangular, columns. In this caſe it is called by the name of *Baſaltes*: but that which is amorphous, or breaks in large, thick, ſquare pieces, is called by the general name of *Trapp*.

When heated red hot, and quenched in water, it becomes by degrees of a reddiſh brown colour.

It melts *per ſe*, in a ſtrong heat, into a ſlag.

Borax diſſolves it by fuſion in the *dry way*; but mineral alkaly does not entirely. *The Editor.*

[*b*] The black variety (3. *a.*) is ſometimes found ſo compact and hard, as to take a poliſh like the black agate; it melts, however, in the fire to a black glaſs, and is, when calcined, attracted by the loadſtone. Such a kind is found in the pariſh of Arla in the province of Sodermanland. *The Author.*

The touch-ſtone, or *Lapis Lydius*, has ever been, and is ſtill now, one of the coſtly toys of ſilly *virtuoſi*. Any black pebble, or a piece of black flint, does the ſame ſervice as the very beſt *Lapis Lydius* of Aſia. Even a piece of glaſs, made rough with emery, is ſucceſsfully employed by our market dealers to diſtinguiſh gold pieces from counterfeits, both by the metallic colour, and by the teſt of *aqua fortis*. The Editor.

SECT. 411. (268.)

H. Amygdaloides. Saxum baſi jaſpidea martiali, cum fragmentis ſpati calcarei et ſerpentini, figurâ elliptica [a]. Mandelſtein of ſome.

It is a martial jaſper, in which elliptical kernels of calcareous ſpar and ſerpentine-ſtone are included.

a. Red, with kernels of white limeſtone, and of a green ſteatites. From Gello and Gullo in Norway, and the Hartz in Germany.

This is of a particular appearance, and when calcined is attracted by the loadſtone; it decays pretty much in the air, and has ſome affinity with the Trapp (Sect. 410.) and alſo with the porphyry (Sect. 409.) There are ſometimes found pieces of *native copper* in this ſtone at Gullo.

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[a] Theſe are the *carpolithi*, or fruit ſtone rocks of the Germans, D. C. Bertrand aſſerts, that the *Amygdaloides*, or *Amygdalites*, are thoſe ſtones which appear to be compoſed of ſuch elliptical figures as petrified almonds, although in fact they are nothing elſe but ſmall oblong pieces of calcareous ſtone, rounded by common attrition, and ſometimes ſmall muſcle-ſhells, connected by a ſtony concretion. But the *carpolithi*, or fruit ſtone rock, is a general name given, by the foſſil writers, to all ſorts of ſtony concretions which repreſent any fruit whatever, of a larger, or ſmaller, ſize than almonds commonly are. *See Bertrand's* Univerſal Dictionary of Foſſils. *The Editor.*

SECT.

SECT. 412. (269.)

I. The *Greonſten* of the Swedes. *Saxum compoſitum mica et hornblende.* Sect. 137.

Its baſis is hornblende, interſperſed with mica. It is of a dark green colour, and is dug in ſeveral places in Smoland, where it is employed in the iron furnaces, as a flux to the bog ore (Sect. 335.) It is alſo found in other places, as at Rettwik in Dalarne, and in the neighbourhood of ſome of the iron mines.

SECT. 413. (270.)

K. The granites. *Saxum Compoſitum*, feltſpato micâ and quartzo, *quibus accidentaliter interdum* hornblende, ſteatites, granatus et baſaltes *immixta ſunt* [*a*].

Its

[*a*] The granite is called alſo *Moor-ſtone* in England: it conſiſts of diſtinct maſſes of various ſtones mentioned by the noble author; or the greateſt part of them, firmly compacted together. Their proportion and ſize are extremely variable, as well as their colour. The *quartz*, *feltſpar*, and *mica*, conſtitute the hardeſt ſort of granite, the moſt anciently known. That into which the *ſhoerl* enters, is more ſubject to decompoſition. The granite never has any particular texture or regular form, but conſiſts of enormous ſhapeleſs maſſes, of great hardneſs,

Its principal conſtituent parts are *felt ſpar* or *rhombic-quartz*, *mica*, and *quartz*.

It is found.

1. Looſe or friable, *Particulis conſtans parum coherentibus.*

This is uſed at the braſs works to caſt the braſs in, and comes from France.

2. Hard and compact, *Granites durus.*

a. Red.

1. Fine-grained, from Swappawari at Tornea in Lapland.

2. Coarſe-grained, from Biſpbergs Klack, in the province of Dalarne.

b. Grey,

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* In the finer granites, the *quartz* is tranſparent; in others generally white or grey, violet or brown. The *feltſpar white*, *yellow*, *red*, *green*, or *black*, is generally the moſt copious ingredient. The *mica* is alſo *grey*, *brown*, *yellow*, *green*, *red*, *violet*, or *black*, and is commonly leaſt copious. The *ſhoerl* is generally *black*, and abounds in the granites that contain it.

Hence the colour of granites chiefly depends on that of the ſpar or ſhoerl. The *red* granites conſiſt commonly of white quartz, red feltſpar, and grey mica. The *grey* of white quartz, grey or violet feltſpar, and black mica. The *black* commonly contain ſhoerl inſtead of feltſpar: and the *green* commonly contain green quartz.

If granite be expoſed to the flame, urged by a blow-pipe, its different concretions ſeparate from each other. In a crucible, Mr. Gerhard found the feltſpar of a piece of granite melted into a tranſparent glaſs; under it the mica lay in the form of a black ſlagg, and the quartz remained unaltered. But when all three were powdered and mixed, it melted ſomewhat better; yet ſtill the quartz may be diſtinguiſhed by the help of a lens. This well explains why ſmall white grains are frequently found in lavas. The experiments of Meſſ. d'Arcet and Sauſſure perfectly coincide on this ſubject.

The

b. Grey, with many and various colours, found on the coaſt round Stockholm and Norland.

The Granites are ſeldom ſlaty or laminated, when their texture is cloſe, and the harder particles, as the feltſpat or rhombic quartz, the quartz, and the ſhirl, predominate in it. They admit of a good poliſh, for which reaſon the Egyptians in former times, and the Italians now, work them into large pieces of ornamental architecture, for which purpoſe they are extremely fit, as they do not decay in the air.

The mixture of mica prevents the ſilex or quartz from cracking or ſplitting; and hence its infuſibility and advantageous uſe in furnaces.

The *granitone*, mentioned by Ferber in his letters from Italy, is a ſtone compoſed of *feltſpar* and *mica*. A ſubſtance of this kind, which moulders by being long expoſed to the air, is found in Finland; it is ſaid to contain ſometimes *ſaltpetre*, and ſometimes *common-ſalt*. It is there called *Rapakivi*. Wallerius deſcribes 18 ſpecies of granites, beſides many other granatic ſtones, on which the curious reader may conſult his Mineralogic Syſtem of the edition in 1778. *The Editor, chiefly from* Kirwan.

SECT. 414. (271.)

2. Conglutinated Saxa, *Saxa conglutinata.*

A. Of larger or broken pieces of ſtones of the ſame kinds conglutinated together, *Saxum conglutinatum fragmentis lapidum. Breccia* [*a*].

1. Of

[*a*] The Stones called *Ludi Helmontii*, or *Paracelſi*, have ſome ſimilarity, in their form, to the *breccia* of this Section; for they are compoſed of various lumps of a marly whitiſh-brown matter, ſeparated into a great number of polygonous compartments, of various ſizes, formed of a whitiſh-yellow cruſt of a red calcareous ſpar, ſometimes pyritous, which often riſe a little above the external ſurface, and incloſe each of them on the inſide. According to Bomare, the *Ludus Stellatus Helmontii*, found in the county of Kent, is covered with a kind of ſtriated ſelenite, reſembling the zeolite.

They are for the moſt part of a globoſe figure, ſeldom flat, but often convex on the outſide. And ſometimes with a concave ſurface.

According to Wallerius, the *Ludus Helmontii* loſes by calcination about half of its weight; and, on being urged by fire, is melted into a black glaſſy ſlag. It effervesces ſtrongly with *aqua fortis*, and this ſolution is of a yellow colour. But what ſeems very extraordinary, by adding to it ſome oil of tartar *per deliquium*, bubbles are produced, from which a great number of ſlender black threads, or filaments, are produced, ſticking like a cobweb to the ſides and bottom of the veſſel.

Theſe ſtones are found quite ſeparate by themſelves, as well as various *ſtalagmites* and *cruſtaceous bodies*, on the ſtrata of argillaceous earth, in various parts of Europe, chiefly in Lorrain, Italy, England (in the counties of Middleſex and Kent), and elſewhere.

Wallerius

1. Of limeſtone cemented by lime, *Saxum conſtans fragments lapidis calcarei, calce conglutinatis.*

a. The calcareous Breccia, *Breccia calcarea*; The *Marmi Brecciati* of the Italians.

When theſe kinds have fine colours, they are poliſhed and employed for ornaments in architecture, and other œconomical uſes; they come from Italy.

b. The *Lumachella* of the Italians, or ſhell marbles. Theſe are a compound of ſhells and corals, which are petriſied or changed into lime, and conglutinated with a calcareous ſubſtance. When they have many colours, they are called marbles, and employed for the ſame purpoſes as the preceding, likewiſe from Italy, from Bergen in Norway, and Offerdal in the povince of Jemteland. In the iſland of Gottland there is found one of this kind of one colour only, which on that account is not called marble, or uſed as ſuch. At Balsberget in the province of Skone, is found of a white lumachella, of weak colours.

Wallerius ranges the *Ludus Helmontii* among the *tophi*, in the *Spec.* 425, of his Syſtem of Mineralogy. Paracelſus had attributed to theſe ſtones a *Lithontriptic* power, and Dr. Grew ſays, that they are *diuretic*; but there is not the leaſt proof of their really poſſeſſing ſuch qualities. *The Editor.*

SECT.

SECT. 415. (272.)

2. Of kernels of jaſper cemented by a jaſpery ſubſtance, *Saxum fragmentis jaſpidis materiâ jaſpideâ conglutinatum. Breccia Jaſpidea. Diaſpro brecciato* of the Italians.

Of this kind ſpecimens from Italy are ſeen in collections. A coarſe Jaſper Breccia is ſaid to be found not far from Frejus in Provence in France.

SECT. 416. (273.)

3. Of ſiliceous pebbles, cemented by a jaſpery ſubſtance, or ſomething like it, *Saxum ſilicibus amorphis materiâ jaſpideâ conglutinatis.* The plum-pudding ſtone of the Engliſh. *Breccia Silicea.*

Its baſis, which is likewiſe the cement, is yellow, wherein are contained ſingle flinty or agaty pebbles, of a grey colour or variegated. This has a very elegant appearance when cut and poliſhed. It is found in England.

SECT.

SECT. 417. (274.)

4. Of quartzoſe kernels combined with an unknown cement, *Saxum fragmentis quartzoſis conglutinatis. Breccia quartzoſa.* Found in the provinces of Jemteland and Smoland.

SECT. 418. (275.)

5. Of kernels of ſeveral different kinds of ſtones, *Saxum fragmentis variorum ſaxorum conglutinatis. Breccia ſaxoſa.*

a. Of kernels of porphyry, cemented by porphyry or a coarſe jaſpery ſuſtance, *Breccia porphyrea*, from Serna Fiell, and Hykieberget in the province of Dalarne.

b. Of kernels of ſeveral ſaxa, *Saxum fragmentis variorum ſaxorum compoſitorum conglutinatis. Breccia indeterminata* [a].

[a] The above mentioned Brecciæ require the diſtinctions here made between them, but which perhaps may ſeem to be carried too far, ſince their particles are ſo large and perfect as to be eaſily known from one another. Theſe ſtones are a proof both of thoſe ſubverſions which the mountains in many centuries have undergone, and of ſome hidden means which nature makes uſe of in thus cementing different kinds of ſtones together. Any certain bigneſs for the kernels or lumps in ſuch compounds, before they deſerve the name of Breccia, cannot be determined, becauſe that depends on a compariſon which every one is at liberty to imagine. At one place in the mountain called Hykieberget, the kernels of porphyry have a diameter of ſix feet, while in other places they are not bigger than walnuts. At Maſſewala the kernels have a progreſſive ſize down to that of a fine ſandſtone. Moſt of this kind of ſtone is fit for ornaments, though the workmanſhip is very difficult and expenſive. *The Author.*

Is

Is found in looſe ſtones in Dalarne, originally broken from the Fiell tracts in Serna, which conſiſt of nothing elſe but conglutinated ſtones.

c. Of conglutinated kernels of ſandſtone, *Saxum fragmentis conſtans ſaxorum conglutinatorum. Breccia arenacea.*

This kind conſiſts of ſandſtones (Sect. 419.) kernels, which have been combined a ſecond time together. This is alſo found in looſe ſtones in Dalarne, and are perhaps originally broken from the above-mentioned Fiell in Serna.

SECT. 419. (276.)

B. Conglutinated ſtones of granules or ſands of different kinds, *Saxum conglutinatum granulis ſeu arenâ variorum lapidum.* Sandſtone, *Lapis arenaceus* [*a*].

In this diviſion are reckoned thoſe which conſiſt of ſuch minute particles, that all of them

[*a*] Sandſtones are of great uſe as materials for buildings which reſiſt fire, air, and water. Some of them are ſoft while in the quarry, but harden in the open air. The looſe ſandſtones are the moſt uſeful: but the ſolid and hard ones, ſuch as *c.* and *d.* crack in the fire, and take a poliſh when uſed in grindſtones. however, though the Burſwik's ſtone (1. *b.*) is pretty looſe

them cannot eaſily be diſcovered by the naked eye. The greateſt part, however, conſiſt of quartz and mica, which ſubſtances are the moſt capable of being granulated without being brought to a powder.

I think I have reaſon to conſider this kind in regard to the ſubſtance which has ſerved as a cement to combine them, although it is not always perfectly diſcernible.

1. Cemented by clay, *Lapis arenaceus glutine argillaceo.*

a. With an apyrus or refractory clay, *Argillâ porcellanea.*

It is found under the ſtratum of coal in the coal-mine at Boſerup in Skone; is of a looſe texture, but hardens, and is very refractory in the fire.

b. With common clay, *Argillâ communi*, from Burſwick in the iſland of Gottland.

2. With lime, *Lapis arenaceus glutine calcareo*; reſembles mortar made with coarſe ſand.

a. Conſiſting of tranſparent and greeniſh grains of quartz and white limeſtone; from the iſland Iſo, near Beckaſkog in Skone.

b. Of

in its texture, it is nevertheleſs unfit for buildings which are expoſed to fire or open air, becauſe it breaks to pieces and melts in the fire, and in the air it attracts the moiſture, decays in proceſs of time, and cracks in the cold, which proceeds from the included kernels of clay expanding themſelves when they grow wet. Sand-ſtones ought therefore to be very nicely examined before they are employed for the uſual purpoſes.

There

b. Of no viſible particles, from France and Livonia. This is of a looſe texture, and hardens in the air.

3. With an unknown cement, *Lapis arenaceus glutine incognito, forſan argillaceo.*

a. Looſe, from Helſingberg in Skone.

b. Harder, from Roſlagen, Orſa, and Kinnekulle.

c. Compact, from Gefle in the province Geſtrikeland, and the lake Malaren.

d. Very hard, from Serna Fiell or Fells in Dalarne; it is alſo found in great abundance in looſe ſtones at Guſtavsſtrom, and at Siliamfors in the pariſh of Mora in Dalarne.

4. Cemented by ruſt or ochre of iron, *Lapis arenaceus ochrâ martis conglutinatus.* Is found in form of looſe ſtones at ſeveral places, and ought perhaps to be reckoned among the *Minerae Arenaceae* or Sand-Ores of Sect. 420; at leaſt when the martial ochre makes any conſiderable portion of the whole.

SECT.

There are many quarries of ſandſtones in Sweden, but no enquiry has been made if any of them, and which can be employed in the larger works, inſtead of the Engliſh, and in the ſmaller manufacturies, inſtead of the Bohemian ſandſtones. Such enquiries are of greater conſequence, in proportion as thoſe manufactures increaſe wherein they are wanted.

It muſt be remarked, that the working maſons, or ſtone-cutters, ought to wear a piece of frieze or baize before their mouth and noſe, in order to preſerve themſelves from a premature death, which is unhappily at preſent the caſe with them in the pariſh of Orſa in Dalarne, and in other places.

But

SECT. 420. (277.)

C. Stones and ores cemented together, *Saxum fragmentis conſtans lapidum et minerarum conglutinatis. Mineræ Arenaceæ.*

1. Of larger fragments, *Fragmentis lapidum et minerarum majoribus.*
   a. Mountain green, or *Viride Montanum Cupri*, and pebbles cemented together, from Siberia.
   b. Potters lead ore, with limeſtone, ſlate-kernels and ſhells from Gragrufvan at Boda in Rettwik, and in Dalarne.
   c. Yellow or marcaſitical copper ore, with ſmall pebbles,

But limeſtone is not found to have this bad effect. *The Author.*

To the above we may add *Grit*-ſtone of greater or leſs hardneſs, moſtly of a grey, and ſometimes of a yellowiſh colour; compoſed of a ſiliceous and micaceous ſand, and rarely of a ſparry kind, with greater or leſſer particles, cloſely compacted and united by an argillaceous cement. It gives ſome ſparks with ſteel, is indiſſoluble for the moſt part in acids; and vitrifiable in a ſtrong fire. It is uſed for mill-ſtones, and whet-ſtones; ſometimes for filtering-ſtones and for building. *Fabroni.*

N. B. The Argillaceous *grit* has been deſcribed in Sect. 150, p. 260.

SECT.

SECT. 421. (278.)

2. Of ſmaller pieces, *Granulis lapidum et minerarum* [a].
   a. Potters lead ore with a quartzoſe ſand, from Eiffelsfeldt near Cologn in Germany.
   b. Mountain green with ſand, from Siberia.
   c. Cobalt ore with ſand.
   d. Martial ochre with ſand.

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[a] The *Mineræ Arenaceæ* or Sand-ores, cannot reaſonably be ſeparated from the ſand-ſtones, ſince they are produced in the ſame manner; beſides, when they are poor in yield, they are alſo employed to the ſame purpoſe, becauſe it is not eaſy to ſmelt the metal out of them. The ſand-ores, beſides, cannot be ranked in a Mineral Syſtem as ſeparate ſpecies of ores, becauſe they would then be arranged with reſpect to the kind of ſtone in which the ore occurs, and not the ore itſelf, which caſe cannot be admitted here. It might be urged, that ores, mixed with the ſtones of the very load, and not in form of ſand ores, ought as well as them to be ranked among the compound ſaxa: but in that caſe there would be no end of ſpecies, nor could they ever be reduced into any order. *The Author.*

SECT.

SECT. 422. (279.)

OBSERVATIONS on the SAXA or STONES.

Beſides the advantages which may accrue to œconomy by a perfect knowledge of the Saxa, the miners or ſubterranean geographers expect alſo another future benefit from it, viz. that of concluding, from many obſervations, whether all the Saxa are to be equally attended to; for example, whether in ſome of them veins or ſtrata of ores may be expected, and whether thoſe are only of certain kinds; whether others are every where found deſtitute of any ore whatſoever; which of them are obſerved to form coats on the ſurface of the rock, that cover other kind of ſtones, or veins and ſtrata of ores, &c. If no general rules can be deduced from ſuch obſervations, there is a probability, at leaſt, of gaining ſome knowledge that may be peculiar to certain countries; and this opinion is already in ſome places confirmed by experience. Hence it may be concluded, how neceſſary it is to communicate all ſuch obſervations which, for the above-mentioned purpoſes, ought to be made over the whole globe, and alſo to agree on fixing certain names on the *Saxa*, in order to avoid too great a prolixity in their deſcriptions. It is

with this intention I have here, as a ſpecimen, given ſpecific names to thoſe Saxa which are found in this northern country, and are known to me, wiſhing at the ſame time to be acquainted with a method to diſtinguiſh them more eaſily and to better purpoſe.

This procedure will be found ſtill more neceſſary and uſeful, as the world ſeems reſolved ſoon to aboliſh the ſuperſtition of the Hazel Rod or *Virgula Divinatoria*, and that we have by means of obſervations already gained too much experience to believe, that the ſtrata of earths and ſtones are placed equally and in the ſame order and ſituation over the whole earth; which ſome, however, in theſe our times have even endeavoured to prove, while others have made a ſecret of it, in hopes of enriching themſelves.

SECT. 423. (280.)

The SECOND ORDER.

MINERAL-CHANGES, or the PETRIFACTIONS.

Mineralia-Larvata, vulgo *Petrefacta* [a].

Are mineral bodies in the form of animals or vegetables, and for this reaſon no others belong to

[a] The Noble Author has very judiciouſly confined to the 13 following ſmall Sections, all that is worthy of being known by mineralogiſts about petrifications, a ſubject upon

to this order, than ſuch, as have been really changed from the ſubjects of the other two kingdoms of nature.

There is more difficulty to determine the firſt point, viz. from when theſe bodies are to be ſtyled petrefactions, than from when they ceaſe to be ſuch; meanwhile I have, in order to make a trial, conſidered them in the following manner.

SECT.

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which many voluminous works have been given to the public, with immenſe labour and erudition, tho' both were very idly employed. The celebrated Wallerius, not to mention his numberleſs predeceſſors of the ſame ſtamp, has had the patience, to employ no leſs than 270 pages of his Mineralogy, with an account of the *concrete*, *figured*, and *petrified foſſils*, above half (189 pages) of which he has intirely devoted to the laſt kind of bodies. But what is very remarkable, and muſt excite the ſmiles of a ſober reader, is the pompous Greek nomenclature that has been beſtowed upon ſuch trifling and childiſh objects: *phytotypolithes*, *meandrites*, *entomolithes*, *apomoſoſtomes*, *orthoceratites*, &c. are to expreſs *petrified* plants, coralloides, crabs, echinites, and ſhells of ſea-inſects. I ſhall forbear to make any additional notes about theſe matters. But the curious may eaſily apply for information to the *Oryctology*, or *Dictionary of Foſſils*, publiſhed in French by E. Bertrand at the Hague, in 1763, in 2 vols in 8vo.; and to ſome other authors on the ſubject. *The Editor.*

The moſt remarkable obſervations, relative to petrifications, are,

1. That thoſe of *ſhells*, are found on or near the ſurface of the earth; thoſe of *fiſh* deeper, and thoſe of *wood*, deeper ſtill. Shells in *ſpecie* are found in immenſe quantities at conſiderable depths.

2. That thoſe organic ſubſtances that reſiſt putrefaction moſt, are frequently found petrified, ſuch as *ſhells*, and the harder ſpecies of *woods*. On the contrary, thoſe that are apteſt to putrify, are rarely found petrified, as *fiſh*, and the ſofter parts of *animals*, &c.

SECT. 424. (281.)

1. Earthy Changes, *Terræ Larvatæ. Terrificata.*
   A. Extraneous bodies changed into a lime ſubſtance, or calcareous changes, *Larvæ calcareæ.*
1. Looſe or friable, Chalky changes, *Cretæ larvatæ.*
   a. In form of vegetables.
   b. In form of animals.
1. Calcined or mouldered ſhells, *Humus conchaceus*, from the province of Helſingeland, at Uddevalla in the province of Halland, and in the French ſtrata of earth and chalk.
2. Indurated, *Petrefacta calcarea.*
   a. Changed and filled with ſolid lime-ſtone.
1. In form of animals.
2. In form of vegetables.

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3. That they are moſt commonly found in ſtrata of marl, chalk, lime-ſtone, or clay: ſeldom in ſand-ſtone; ſtill more rarely in gypſum; but never in gneiſs, granite, baſaltes, or ſhoerl. But they ſometimes occur among pyrites, and ores of iron, copper, and ſilver; and almoſt always conſiſt of that ſpecies of earth, ſtone, or other mineral, that ſurrounds them; ſometimes of ſilex, agate, or cornelian.

4. That they are found in climates, where their originals could not have exiſted.

5. That thoſe found in *ſlate*, or *clay*, are compreſſed and flattened. *The Editor from* Kirwan.

Found

Found in the iſland of Gottland.

b. Changed into a calcareous ſpar, *Petrefacta calcarea ſpatoſa.*

1. In form of animals.

The ſhells in Balſberget in the province of Skone.

2. In form of vegetables [*b*].

SECT. 425. (282.)

B. Extraneous bodies changed into a flinty ſubſtance. Siliceous changes, *Larvæ.* Theſe arè like the flint,

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[*b*] Shells and corals are indeed compoſed of limy matter, even when their animals ſtill dwell in them; nevertheleſs, although they are not changed in regard to their principle, yet they are reckoned among the petrefactions, as ſoon as the particles of the calcareous ſubſtances have obtained a new ſituation; for example, when they are become ſparry, when they have been filled with a calcareous earth, either hardened or looſe, or when they lie in the ſtrata of the earth. Theſe form the greateſt part of foſſil collections, which are ſo induſtriouſly made, often without any regard to the only and principal uſe they can be of, viz. that of enriching zoology. Mineralogiſts are ſatisfied with ſeeing the poſſibility of the changes the lime-ſtone undergoes in regard to its particles, and alſo with receiving ſome inſight into the alteration which the earth has been ſubject to, from the ſtrata which are now found in it.

The calcined ſhells, of thoſe which have been changed into limy and chalky matter, are fit to make lime, and are ſtill more ſerviceable as a manure. The indurated ſerve only to make grottos. No gypſeous petrefactions are known, if ſuch are not found in the Perſian alabaſter; for Mr. Chardin ſays, that he has ſeen a lizard included in that ſtone. *The Author.*

1. Indurated, *Petrefacta ſilicea.*
   a. Changed into flints.
1. Carnelians in form of ſhells, from the river Tomm in Siberia.
2. Agat in form of wood. Such a piece is ſaid to be in the collection of Count Teſſin.
3. Coralloids of white flint, (*Millepora*) found in Gottland.
4. Wood of yellow flint. Italy, Adrianople, and Loughneagh, a lake in Ireland.

SECT. 426. (283.)

C. Extaneous bodies changed into clay. Argillaceous changes, *Larvæ argillaceæ.*
   a. Looſe and friable.
1. Of porcellane clay.
   a. In form of vegetables.

A piece of white porcellane clay from Japan, with all the marks of the root of a tree, has been obſerved in a certain collection.

   b. Indurated.
1. In an unknown clay. *See page 77. a.*
   a. In form of vegetables. *Oſteocolla.* It is ſaid to be changed roots of the poplar tree, and not to conſiſt of any calcareous ſubſtance. See the *Phyſicaliche Beluſtigugen.*

A ſort of foſſil ivory is ſaid to be found, which has the properties of a clay; but I do not know if it is rightly examined.

SECT.

SECT. 427. (284.)

2. Saline extraneous bodies, or ſuch as are penetrated by mineral ſalts, *Corpora peregrina inſalita. Larvæ inſalitæ.*
   A. With the vitriol of iron, *Vitriolo martis inſalita.*
1. Animals.
   a. Human bodies have been twice found in the mine at Falun in Dalarne; the laſt was kept a good many years in a glaſs caſe, but began at laſt to moulder and fall to pieces.
2. Vegetables.
   a. Turf, and
   b. Roots of trees.

Theſe are found in water ſtrongly impregnated with vitriol; for inſtance, in the moor at Oſterſilfberget in Dalarne. They do not burn with a flame, but only like a coal in a ſtrong fire; neither do they decay in the air.

SECT. 428. (285.)

Extraneous bodies penetrated by mineral inflammable ſubſtances, or mineral phlogiſton, *Corpora peregrina phlogiſtis mineralibus impregnata.*

A. Penetrated by the ſubſtance of pit-coal, *Lithantrace impregnata.*

1. Vegetables, which commonly have been woods, or appertaining to them.

a. Fully ſaturated. *Gagas. Jet. See Sect.* 240. *p.* 473.

The jet is of a ſolid ſhining texture. From England, Boſerup in Skone, and the Black Sea.

b. Not perfectly ſaturated. *Mumia vegetabilis.* Is looſe, reſembles umbre, and may be uſed as ſuch. From Boſerup.

SECT. 429. (286.)

B. Penetrated by rock oil or aſphaltum, *Corpora peregrina petroleo ſeu aſphalto impregnata.*

1. Vegetables.

a. Turf in the province of Skone.

The Egyptian mummies cannot have any place here, ſince art alone is the occaſion that thoſe human bodies have in length of time been penetrated by the aſphaltum, in the ſame manner as has happened naturally to the wood in pit-coal ſtrata (Sect. 428.)

SECT. 430. (287.)

C. Penetrated by ſulphur which has diſſolved iron, or by marcaſite and pyrites, *Pyrite impregnata, Petrefacta pyritacea.*

1. Human.

1. Human.
   a. Bivalves,
   b. Univalves, and
   c. Inſects.
   In the alum ſlate at Andrarum in Skone.

SECT. 431. (288.)

4. Metals in the form of extraneous bodies, *Larvæ metalliferæ.*
   A. Silver, *Larvæ argentiferæ.*
1. Native.
   a. On the ſurfaces of ſhells. England.
2. Mineraliſed with copper and ſulphur.
   a. Fahlertz or grey ſilver ore (Sect. 272. and 276.) in form of ears of corn, &c. and ſuppoſed to be vegetables, are found in argillaceous ſlate at Frankenberg and Tahlitteren in Heſſe.

SECT. 432. (289.)

B. Copper, *Larvæ cupriferæ.*
   1. Copper in form of calx, *Cuprum calciforme corpora peregrina ingreſſum.*
      a. In form of animals, or of parts belonging to them.
1, Ivory, and other bones of the elephant.
   The Turquois or Turky ſtone: It is of a bhueiſh

blueiſh green colour, and much valued in the Eaſt. *See Sect.* 323. *p.* 686.

At Simore in Languedoc bones of animals are dug, which during the calcination aſſume a blue colour; but it is not probable that the blue colour is owing to copper.

SECT. 433. (290.)

2. Mineraliſed copper, which impregnates extraneous bodies, *Cuprum mineraliſatum corpora peregrina ingreſſum.*

A. With ſulphur and iron. The yellow or marcaſitical ore that impregnates

1. Animals.
   a. Shells, from Hagatienns Schurff and Jarlſberg in Norway. Theſe ſhells lye upon a loadſtone,
   b. In form of fiſh, from Eeiſleben, Mansfeld, and Oſterode, in Germany.

B. With ſulphur and ſilver. Grey ſilver ore at Fahlertz, like ears of corn, from the ſlate quarries in Heſſe (Sect. 431.)

SECT. 434. (291.)

C. Changes into iron, *Larvæ ferriferæ.*

1. Iron in form of calx, which has aſſumed the place or the ſhape of extraneous bodies, *Ferrum calciforme corpora peregrina ingreſſum.*

   a. Looſe,

a. Looſe, *Larvæ ochraceæ.*

1. Of vegetables.

Roots of trees, from the lake Langelma in Finland: *See the* Acts *of the* Swediſh Academy of Sciences *for the year* 1742.

b. Indurated, *Larvæ hæmatiticæ.*

1. Of vegetables.

Wood, from Orbiſſau in Bohemia.

SECT. 435. (292.)

2. Iron mineraliſed, aſſuming the ſhape of extraneous bodies, *Ferrum mineraliſatum corpora peregrina ingreſſum.*

a. Mineraliſed with ſulphur. Marcaſite. *Larvæ Pyritaceæ.* Sect. 450.

SECT. 436. (293.)

4. Extraneous bodies decompoſing, or in a way of deſtruction, *Corpora peregrina in gradibus deſtructionis conſiderata.* Mould, *Humus.* Turf, *Turba.*

A. From animals. Animal mould, *Humus animalis.*

1. Shells. *Humus conchaceus.*

2. Mould of other animals, *Humus diverſorum animalium.*

B. Vegetable mould, *Humus vegetabilis* [*c*].

1. Turf,

[*c*] All the kinds of mould contain ſome of the inflammable ſubſtance, which has remained in them from the vegetables or animals; and they are more or leſs black, in proportion

as

1. Turf, *Turba.*

a. Solid, and hardening in the air, *Turba ſolida aëre indureſcens.* Is the beſt of this kind to be uſed for fuel, and comes neareſt to the pit-coals. It often contains a little of the vitriolic acid.

b. Lamellated turf, *Turba foliata.* This is in the firſt degree of the deſtruction.

2. Mould of lakes, *Humus lacuſtris.* This is a black mould, which is edulcorated by water.

3. Black mould, *Humus ater.*

This is univerſally known, and covers the ſurfaces of that looſe earth in which vegetables thrive beſt.

SECT.

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as they contain more or leſs of this phlogiſton. I have ranked them in this place, that they might not be totally excluded. They are elſe a *medium uniens* between all the three kingdoms of nature: and it may reaſonably be aſked, if all ſorts of earth do not in form of very minute particles enter into the compoſition of vegetables and animals, after which they exiſt for ſome time in form of mould, until the phlogiſton is again ſeparated. *The Author.*

The black mould yields by diſtillation an oily and alkaline ſubſtance. *Humus atra* (ſays Wallerius) *deſtilla ime dat* phlegma, *plus minus pro ratione ficcitatis*, 2. Spiritum acrem fœtidum, *qui quo obſcuriori diſtillat colore, eo magis acris & empyreumaticus, non tamen* ſalinus, *utpote nec cum* acidis *nec cum* alkalinis *effervescens, ſed oleoſus* ſpiritui tartari *odore et ſapore ſimilis:* 3. *Et denique* quidpiam oleoſi rubentis.—*In Engliſh.* The black mould affords, when diſtilled, more or leſs phlegm, according to the degree of its dryneſs: 2dly, a ſharp fetid liquor, which is more acid and empyreumatic in proportion as it is of a darker colour: but it neither effervesces with acids nor alkalis; has an oleaginous appearance, and reſembles, both in taſte and ſmell, the ſpirit of tar-

tar

SECT. 437. (294.)

The THIRD ORDER.

NATURAL SLAGS,

Scoriæ Vulcanorum [*d*].

Slags are found in great abundance in many places in the world, not only where volcanos yet

tar and laſtly, a ſmall quantity of a reddiſh oil. *The Editor.*

[*d*] 1. Volcanos, or burning mountains, are peculiar to no climate, and have been obſerved in every quarter of the globe, as Kirwan obſerves. They have no neceſſary or regular connection with thoſe of other mountains; it ſeems, however, that the contrary is ſometimes the caſe, as mount Ætna, or Gibello, in the iſland of Sicily, has been obſerved to have made ſome extraordinary exploſions, when Veſuvius in Italy was in its greateſt convulſions.

2. Theſe burning mountains are of various ſizes, that of *Tana* in the Pacific Ocean is no higher than 450 feet; but others of the kind are conſiderably high. Ætna in the iſland of Sicily is above 24 times higher, *viz.* 10,954 *feet*, according to what is ſaid in the Phil. Tranſ. vol. 67. p. 595. Theſe mountains generally form lofty ſpires internally ſhaped like an inverted cone, placed on a broad baſis, which is upwards; this is called the *Crater* of the Volcano, and through it the lava and other ejected matters generally paſs; though it ſometimes burſts from the ſides, and even from the bottom of the mountain. Sometimes, alſo the crater falls in, and is effaced. In extinguiſhed volcanos it is often filled with water, and forms thoſe lakes that are obſerved on the ſummits of various mountains.

yet exiſt, but likewiſe where no ſubterraneous fire is now known. Yet, according to our opinions, they cannot be produced but by means of

3. Both the crater, and baſis of many volcanos, conſiſt of lavas, either ſolid and intire, or decompoſed, nearly as low as the level of the ſea: but they finally reſt upon *granite*, as the volcanos of *Peru*; or on *Shiſtus*, as the extinguiſhed volcanos of *Heſſe* and *Bohemia*; or, finally, on *lime-ſtone*, as thoſe of *Sileſia*, the *Vicentine Alps*, and mount *Veſuvius* in Italy. The decompoſed and undecompoſed lavas form irregular ſtrata, that are never parallel to each other; and, beſides *iron*, of which they contain from 20 to 25 *per cent.* *ſulphur*, and ſome fragments of *copper*, *antimony*, and *arſenic*, they contain no other ores.

4. The immenſe quantities of matter thrown up, at different periods, by volcanos, without leſſening the apparent bulk of their mountains, ſhew that the ſeat of theſe fires muſt be ſeveral miles, perhaps hundreds of miles, below the ſurface of the ſea; and in fact there are records of various volcanic exploſions under the bottom of the ſea, one of which happened a few years ago near Iceland. And, as *iron* makes from $\frac{1}{3}$ to $\frac{1}{4}$ of all theſe ejections, we may infer, that the interior parts of the earth conſiſt chiefly of this metal, its ores, and thoſe ſtones that contain it, whoſe greater or leſſer dephlogiſtication in different parts may cauſe the variation of the magnetic direction in various places of the globe.

5. It is well known that martial pyrites, being moiſtened, acquire heat, and if there be the concourſe of pure air, it will burſt into actual flame; but when there is no ſuch communication, we may ſuppoſe that the heated pyrites may be in contact with *black wad* (pag. 859), and *petrol* (Sect. 236. and that the flame may be fed by the *vital* or *dephlogiſticated air* that is produced from thoſe ſubſtances which are known to afford it, in the ſame manner as nitre is employed to entertain the flame in the modern manufactories of *vitriolic acid*.

6. As to the exploſion or eruption of the melted and ſcorified matters thrown out by the volcanic mouths, it may naturally ariſe from large quantities of water, which enter by ſome cracks,

of fire. Theſe are not properly to be called natural, ſince they have marks of violence, and of the laſt change that mineral bodies can ſuffer

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cracks, and hollow communications, formed by the weathering of the interior veins of ſoft ſubſtances between the mountains and the ſea, rivers, or ſources of water, in the neighbourhood of them; or elſe the water may be naturally produced within thoſe enormous cavities on the inſide of the volcanic mountains; ſince it has been lately diſcovered (or at leaſt aſſerted) by ſome naturaliſts, that this fluid ſubſtance may be formed by the intimate union and deflagration of *inflammable* and *dephlogiſticated air*.

7. If the maſs of the water be ſufficiently great, it will extinguiſh the fire that had been lighted. On the contrary, if the water be in a leſs proportion, it will ſuddenly be converted into vapour, whoſe elaſtic force is known to be ſeveral thouſand times greater than that of gun-powder. If the ſuperincumbent weight be too great, it may cauſe earthquakes; but it will propel both the melted and diluted matters laterally towards the mouth of the volcano, where, meeting with the leaſt reſiſtance, it will expel them, together with all the unmelted ſtony maſſes it meets with in its paſſage.

8. It is eaſily conceived, that before the denſe, ſoaked, and fuſed matters be ejected, the expanded air of the volcano will firſt be forced out, and carry with it the aſhes and looſer ſtones adhering to its ſides and crater, as have been obſerved by eye witneſſes, and various hiſtorians, to great diſtances. In the exploſion of Veſuvius, on March 31, 1767, there were large blocks of ſtone, above 20 tons or 40,000 pounds weight, blown above 200 feet high according to Hamilton, and 1200 feet according to de la Torre. Bergman ſpeaks of a rocky block of about 1000 cubic feet thrown to the diſtance of half a Swediſh mile. The aſhes of the eruptions, in 1631, went ſo far as *Ragüſa*, *Sardinia*, and even to *Conſtantinople*, as Braccini aſſerts, quoted by B. Dietrich, in his notes to *Ferber's Letters*, where an account of the prodigious quantity and varieties of theſe volcanic ejections may be ſeen.

9. But

ſuffer without the deſtruction of the world; nor are they artificial according to the univerſally received meaning of this word. When we

9. But the baſaltes, among theſe volcanic products, deſerves to be mentioned in a more particular manner. Our author thought that they belonged to a very different kind, and confounded them with the ſhoerls, as appears by his 72d and following ſections, at p. 207, and following, of his edition, where he called the Shoerl, or *Lapis Corneus* of *Wallerius's* firſt edition, by the name of *Baſaltes*. Bergman, in the Sect. 126 of his *Sciagraphia*, pointed out this impropriety, which has been corrected in the preſent edition.

10. Pliny, in his 36 book, chap. 7, aſſerts, that the *baſaltic ſtone* had been diſcovered by the Egyptians in Ethiopia; 2dly, that the name of *Baſaltes* had been given to it; and 3dly, that it poſſeſſed both the colour and hardneſs of iron.

11. Bergman, Guetard, Kirwan, and other philoſophers, ſeem to have decided, upon very plauſible reaſons, which the firſt named philoſopher has judiciouſly expoſed in his Treatiſe de *Productis Vulcanicis*, that the baſaltes have been formed in the *humid way*, from the fluid matters formerly ejected by volcanos; but Deſmareſt, Ferber, Baron de Dietrich, de St. Fond, and other learned men, are of opinion, that the formation of theſe wonderful maſſes were produced *via ſicca*, from the melted or fuſed matters ejected by the ſame vulcanos. The baſaltic ſubſtance is indeed far from the true vitreous ſtate; and, when urged by fire, it runs into a black glaſs, whoſe texture has not the leaſt reſemblance to that of its crude ſtate.

12. Baſaltes are found in two or three general forms; either amorphous in maſſes of all ſizes and thickneſs. Sometimes lamellated like ſlate, and of large dimenſions, and at other times very thick, forming ſolid blocks from the ſmalleſt ſize to that of the whole mountains. The trapp, already mentioned in Sect. 410, is of this kind.

13. The moſt remarkable baſaltes are thoſe of a columnar form; they are properly *polyhedrical* and polygonal, being compoſed of flat ſides, which form a great variety of angles between themſelves; but they cannot be called *cryſtaliſed*,

we perhaps in future times by new discovered means may be able to find out of what sort of earth stones are compounded, we shall still be forced

ised, because they never exhibit any regular figure or symmetrical disposition of parts, and of course they cannot be ranked among *crystals* or *crystallised* bodies. Some, though very rare, have a cylindrical form, like columns, so that the transverse section is a true circle, and even some have been found of a flattened shape, having an ellipsoide for their lateral section.

These polygonal columns consist of many sides, from 3 to 11, and sometimes more, seldom forming similar angles; and as to their size, they vary very much. Some are found, though very rarely, so small as to deserve the name of miniature, *viz.* from 4 to 5 *tenths* in breadth to one inch and a half in length; but the most common sized ones are from 5 to 11 and more inches in diameter, and from 1 to 16, 25, and 30 feet high.

14. Bergman asserts, that basaltic columns have been found of 30, 40, and more feet high, and of enormous thickness. Many of great dimensions are found, as Faujas mentions, near the castle of *Bastide*, and in the mountain of *Chenevari*, in the province of *Viverais* in France, measuring, 3 ½ *feet* in thickness, and 15 or 16 feet long. There are others still more voluminous in the *Expailli* of *Velai* in *Auvergne*, in the states of Venice, chiefly about *Vicenza* in *Sicily*, and in the province of *Antrim* in Ireland. One octogonal prism, from this last place, is kept in the *British Museum* of London, whose weight was guessed by Brunnich to be about 1300 pounds, and no doubt but much larger still may be found in the same and other places.

15. Solid bowls, or globes, and even of an oval form, have been found also, formed out of the basaltic substance. Some of an uniform mass, and others composed of concentric crusts, which may be separated by the blow of a hammer. A large and very singular one of this kind is represented in the last plate of the volcanic *Mineralogy of Faujas de St. Fond* printed in 1784. The natural process by which poligonous basaltes sometimes become of a spherical form, by losing their corners, was first observed by Messieurs the *Mar-*

forced to ſtop at the ſurface of them, and be contented with knowing that they contain a little

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quis, de Laizier, Beſſon, and *Delarbre*, in the mountains of Auvergne in France. *See the* account *given, by the laſt named gentleman, in* Journal de Phyſique, *for Auguſt* 1787, p. 135.

16. Another ſort of baſaltes ſhews a fibrous texture, like the Aſbeſtus, though their colour and component parts are like thoſe already deſcribed.

17. But the moſt numerous columnar baſaltes, in various countries, are of the articulated kind, each conſiſting of many ſmaller priſms of a ſhort and ſimilar form in their ſides, diſpoſed into the ſame number of angles, and under the ſame angular inclination to one another, terminated by two horizontal perpendicular baſes, of which one is concave and the other convex, having a roundiſh prominence in the middle, which fits exactly on the hollow of the next priſm. Theſe polygonous priſms, or columns, ſtand upright, and ſometimes variouſly inclined to the horizon; they ſtand very cloſe to one another, leaving only ſome chinks between themſelves, which ſeldom exceed the breadth of 4 or 5 tenths of an inch, and are filled for the moſt part with a calcareous ſpar, that often covers each priſm like a natural varniſh.

18. This circumſtance demonſtrates, that the volcanic lavas, which formed theſe baſaltic priſms, were firſt in a ſoft ſtate, and that either by ſimply cooling, or by the evaporation of ſome ſubtle mixture, they contracted their dimenſions, forming themſelves into all the varieties of polygonous priſms; ſuch as we obſerve in various ſimilar circumſtances. That kind of Indian ware from China and Japan, whoſe outſide ſurface is cracked into various ſmall polygons, may ſerve as a ſample in miniature of theſe phænomena: and I have ſeen a group of white artificial cryſtals, which aſſumed, by cooling in the oven, a baſaltic form. This laſt has been already mentioned by Sir Wm. Hamilton in the 2d part of Phil. Tranſ. for 1786, p. 375.

19. The calcareous ſpar, juſt now mentioned, ſeem to demonſtrate alſo, that when theſe volcanic fluid ſubſtances were ſettled, and had been already contracted in their dimenſions, they

little iron. Mean while I cannot omit them here, ſince I have conſidered the petrefactions;

they have then been overflowed by an inundation of diſſolved calcareous earth, which covered their ſurfaces, and filled their chinks with thoſe ſparry incruſtations. The ſame Sir Wm. Hamilton, to whoſe zeal we owe great elucidations on theſe ſubjects, affirms, that the lavas, which happened to run in their fluid ſtate to the ſea, from the *Etna*, and from the other volcanic mouths in the iſlands of *Lipari*, have aſſumed the form of priſmatic baſaltes.

20. This regular and cloſe correſpondence of thoſe pieces, that form the horizontal ſurface of the baſaltes among themſelves, muſt leſſen the ſurprize of thoſe who travel in Italy, when they behold the many and extenſive parts of the *Via Appia*, and of other antient pavements ſtill remaining, through many miles, in various roads, in the neighbourhood of Rome, and other parts, formerly inhabited by the Romans. Theſe old pavements are compoſed of large brown or blackiſh angular ſtones, ſo well adapted to each other, that it ſhould require an immenſe labour to be framed by art; but the Romans undoubtedly got them in this form from ſome baſaltic quarries, ſuch as have been lately diſcovered in various parts of Italy. Nevertheleſs, the labour and expence, of extracting, carrying, and fitting them to their public roads, muſt have been extremely toilſome. The greateſt part of thoſe large tracts of ſimilar volcanic productions, not only in the Iriſh county of Antrim, but thoſe of Vivarais and Auvergne in France, in Italy, and in Germany, as well as in various other provinces of Europe, afford certainly the ſame conveniency for paving modern roads; but in all probability they never will vie, at leaſt by their durability, for ſo many centuries to come, with the Roman ones. The ancient undertakings, even after ſo many ages, ſtill appear to have been made on a gigantic ſcale, whilſt the moſt magnificent attempts of our times only ſeem to be like the work of a race of puny pigmies, in compariſon to the antient monuments.

Baſaltes are of various colours; for the moſt part brown, or black, of different ſhades, ſome of as deep a *black* as the beſt ebony; ſome are *blueiſh*, *greeniſh*, *grey*, and of an ochreous *yellow*, or *reddiſh* colour; ſome are variegated with

tions; and therefore I will enumerate ſome of them, according to their external marks.

ſmall ſpots of whitiſh ſhoerls, and of different colours; and ſome are *tranſparent* like glaſs, which laſt are employed with ſucceſs in blackglaſs manufactories, for making bottles. To this laſt belong the *Lapis Obſidianus* of Pliny, the *Iſlandic Agate* of the next Section, and the *Lapis Gallinaçeous* from Peru, in the Spaniſh America, which by its beautiful blackneſs aſſimilates to a large black bird of the crow kind in that country, called *Gallinaço*.

22. Mr. Latrobe told me that he had ſeen in Upper Luſatia, in the manor of *Bertholſdorff* near *Herrnhut*, the chief ſettlements of the Moravian brethren, a rock of granite, which apparently burſts aſunder by a vein of concentric baſaltes. This ſeems to have a communication with a conic hill of conſiderable height, called the *Hutberg*, which conſiſts of baſaltes, covered with mould, and has ſeveral parties of baſaltic columns at the top: the country all around is covered with large blocks of granite.

23. There are alſo found baſaltes, with other various extraneous bodies, incloſed in their maſſes, which equally ſhew the fuſed ſtate they had originally ſuffered; among theſe are cryſtallized *ſhoerls*, both white and black, calcareous *ſpars*, *zeolites*, *cryſolites*, *ſaphyrs*, *garnets*, pieces of *porphyry*, *granite*, and of other ſtones. But the ſhoerls and white garnets that are found imbeded within the maſs of baſaltes, they ſeem rather formed *via ſicca*; as Ferber aſſerts, in his *eleventh letter*.

24. The maſs which is formed into the baſaltic ſhape, ſeems to be of the ſame very kind of the lava; but more elaborated, perhaps by a longer boiling, baking, or roaſting, on the bowels or bottom of the vulcanic crater. Bergman, who analyſed various maſſes of baſaltes, found that at a *medium*, their component parts conſiſt of 52 parts, or hundreds of *ſiliceous earth*; 15 of *argillaceous*; 8 of *mild calcareous earth*, and 25 of *iron*. And Faujas de Saint Fond gives the following proportions, *viz.* 46 of *ſiliceous*, 30 of *argillaceous*, 10 of *calcareous*; 6 of *magneſian earth*; and 8 of *iron*. The Editor.

SECT.

SECT. 438. (295.)

A. Iceland agat, *Achates Iſlandicus niger.*

It is black, ſolid, and of a glaſſy texture; but in thin pieces it is greeniſh and ſemi-tranſparent like glaſs bottles, which contain much iron. The moſt remarkable is, that ſuch large ſolid maſſes are found of it, that there is no poſſibility of producing the like in any glaſshouſe.

It is found in Iceland, and in the iſland of Aſcenſion. The jewellers employ it as an agat, though it is too ſoft to reſiſt to wear. *See N°. 21 of the preceding* note; and p. 473, and p. 923.

SECT. 439. (296.)

B. Rheniſh millſtone, *Lapis molaris Rhenanus.* Is blackiſh grey, porous, and perfectly reſembles a ſort of ſlag produced by Mount Veſuvius. If I am miſtaken in this, I hope that ſomebody elſe will deſcribe the conſtituent parts of this millſtone.

SECT. 440. (297).

B. Pumice ſtone, *Pumex* [*e*].

It is

[*e*] The pumice ſtone, or *Bimſtein* of the Germans, is rather a volcanic ejection, than a volcanic production. It is

It is very porous and bliſtered, in conſequence of which it is ſpecifically very light. It reſembles that frothy ſlag which is produced in our iron furnaces.

1. White.
2. Black.

The colour of the firſt is perhaps faded or bleached, becauſe the ſecond kind comes in that ſtate from the laboratory itſelf, viz. the volcanos.

SECT. 441. (298.)

D. Pearl ſlag, *Scoriæ conſtantes globulis vitreis conglomeratis.*

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of a *white*, *reddiſh-brown*, *grey*, or *black* colour. Its conſiſtence is rough and porous, conſiſting of ſlender fibres parallel to each other; is very light, and ſo that it ſwims on water, and difficultly gives fire with ſteel. It ſeems to have originally been an aſbeſtos decompoſed by the action of fire; but, on obſerving the appearance of that glaſſy-ſlag produced in the iron furnaces, which quite reſembles the pumice-ſtone, and is produced from the calcareous fluxes to help the fuſion of the ore, it may rather be attributed to that kind of froth which muſt be formed at the top of the fuſed matters in the volcanic craters. 100 parts, according to Bergman, contain from 6 to 15 of magneſia, with a ſmall proportion of calcareous earth, and the moſt part of ſilex.

Mr. Dolomieu has lately diſcovered at *Stromboli* another ſort of *pumice*, which ſeems to be a ferrugineous granite, altered by fire.

The pumice-ſtone is commonly employed to rub ſmooth and poliſh the ſurface of metals, wood, paſteboard, ſtone, and of other matters, as, by the harſh and brittle particles of its ſubſtance, it carries off the cruſt and inequalities of the ſurface that is wanting to be evened and ſmoothed. *The Editor.*

Is compounded of white and greeniſh glaſs particles, which ſeem to have been conglutinated while yet ſoft, or in fuſion. It is found on the iſle of Aſcenſion.

SECT. 442. (299.)

E. Slag-ſand or aſhes. *Scoriæ pulverulentæ, Cineres Vulcanorum,*

This is thrown forth of the volcanos, in form of larger or ſmaller grains. It may perhaps be the principle of the Terra Puzzolana (Sect. 342. *a.*), becauſe ſuch an earth is ſaid at this time to cover the ruins of Herculanum near Naples, which, hiſtory informs us, was deſtroyed by a volcano during an earthquake.

SECT. 443. (300.)

OBSERVATIONS on the preceding SLAGS [*f*].

It ſeems as if we could not go any farther in the arrangement of bodies belonging to the

[*f*] The ſubſtances ejected by volcanos are, *phlogiſticated*, *fixed*, and *inflammable air*; *water*, *aſhes*, *pumice ſtones*, *ſtones* that have undergone no fuſion, and *lavas*. The water proceeds partly from the condenſed vapours, and partly from the combination mentioned at N° 6 of the laſt note [*d*], or at leaſt from that which has cauſed the exploſion, as already deſcribed in the ſame note.

the mineral kingdom, than to the black mould (Sect. 436.) and the ſlags, as being the extremes.

However, if theſe ſlags likewiſe decay, and in length of time become an earth, which poſſibly may happen; there is then a new ſubſtance beyond them, which however may return back and circulate again in ſome known form. It is obvious how the old heaps of ſlags from the iron furnaces decay, and at laſt produce vegetables, which cannot be aſcribed to a black mould alone carried thither by the wind. The ſame may perhaps happen with the natural ſlags in the open air; but we do not know if it is ſo, nor what different forms this and every other earth, which circulates in animals and

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If the aſhes of the volcano are plentifully moiſtened with water, they produce that kind of *tufa* or *tophi*, *traas*, and *pori*, all which are nearly of the ſame kind. Great heaps of *tufa*, or *tophi*, are found in Italy, forming various hills, and covering large tracts of land, from whence it is cut and carried for making the walls, vaults, and upper ceilings of houſes; it is a very ſoft kind of ſtone, extremely advantageous for theſe purpoſes, on account of its ſmall weight, and of being eaſily cut into any form. The inhabitants of Umbria, and other parts of Italy, dig, with very little labour, various ſubterraneous, corridores, and large excavations under earth, where they keep wines, and many proviſions quite free from the irregularities and exceſſes of temperature. *See the* notes *to p.* 735.

The lava, according to Kirwan, is the immediate produce of liquefaction, or vitrification, by the volcanic fires; and muſt be diſtinguiſhed from their other productions of the ſame ejected at the ſame time, having been affected by the water, either in a liquid or fluid ſtate.

All lavas are more or leſs magnetic; give fire with ſteel, are generally of a granular texture, and fuſible *per ſe*. Moſt

and vegetables, further aſſumes. However, in ſuch circumſtances, as their particles become or are already very minute, and moſt part of the phlogiſton becomes volatile, when acted upon by heat or fire, it ſeems probable, that, by a ſlow ſepartion of the phlogiſton, or a union by means of ſalts, this earth is more apt to become a clay, provided it is not by any previous revolution laid in ſuch places as to change it into ſlate, pit-coal, &c.

If at any time it ſhould happen that a volcano ſhould burſt out of a mountain, whoſe ſtrata we knew before, we could at leaſt imagine ſome reaſons for this wonderful effect. However, the learned would nevertheleſs, perhaps, want ſome knowledge about the ſubſtances

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of them are decompoſable by long expoſure to the air, ſooner or later, according to the proportion of iron and calcareous earth they contain; and according as they were more or leſs perfectly melted. By the obſervations of Sir William Hamilton, the lava of *Veſuvius* forms one or two feet of mould in 1000 years. This bed being afterwards covered with freſh lava from another exploſion; and this, after mouldering by thoſe of ſtill later eruptions, affords ſome ground for calculating the age of the volcano, at leaſt within certain limits. Recupero, a canon of the cathedral of Catania in Sicily, ſays, that if it be allowed to judge by the number of the lavas found in Mount Etna, diſpoſed in alternate ſtrata with vegetable earth, there muſt have been the ſpace of 14,000 years to be formed from the deepeſt to the upper one.

Lavas may be reduced to theſe 3 varieties, *viz. cellular*, *compact*, and *vitreous*. The *cellular* underwent only the firſt and loweſt degree of fuſion, being juſt mollified and heated to expell the *fixt air* contained in the argillaceous particles. Hence they abound in ſmall cavities ariſing from the

ſtances of the ſtrata, and the manner of their formation; ſince in this circumſtance water and other obſtacles have hindered people too much from making the due obſervations thereon.

Meanwhile, the more we conſider, on the one part, all the modification and alterations the earths undergo by means of fire and water, by the free or impeded acceſs of the air, by the volatility and attraction of the acid ſalts, whereby are produced ſolution and hardening, compoſition and ſeparation; and, on the other part, reflect on the ſhortneſs of a man's life, perhaps alſo dedicated to other buſineſs, on the difficulty of obſerving the ſubterraneous effects, and

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the expanſion of that air, after it had recovered its elaſtic ſtate; on this account they are often ſo light, as to float for ſome time on water, and have been miſtaken for pumice-ſtones. Their colour is black, grey, brown, or reddiſh brown; and their cavities are even filled with cryſtallizations: of this ſort is the black cellular mill-ſtone of the *Rhine*, mentioned in Sect. 439.

Theſe ſtones contain from 45 to 50 *per cent.* of *ſilex*; from 15 to 20 of *iron*; 4 or 5 of pure *calcareous earth*; and the remainder is *argill.*

The *compact lavas* have undergone a more perfect degree of fuſion; yet they are not entirely deſtitute of cavities, which contain finer cryſtals, or pieces more perfectly vitrified; their colour is black or brown; their fracture is ſtill obſcure and not glaſſy, as the ſtones themſelves are opake. If not cracked, they give a clear ſound when ſtruck. Their conſtituent parts are the ſame as the preceding ones. The uſual fluxes attack them with difficulty; and microcomic ſalt has ſcarcely any power over them.

The *vitreous* lava has been more compleatly melted, and forms vitrifications of different colours, generally black or aſh-

and on ſeveral things, which prevent the making diſcoveries, by which we might find out ſome eaſier means to attain true knowledge by judicious experiments; the more we ſhall find what is wanted to form mineral ſyſtems, and for this reaſon be apt to excuſe the faults of thoſe which have been hitherto publiſhed.

From thoſe who of themſelves are ſuſceptible of theſe ſentiments, I ſuffer with pleaſure that judgement, which I am myſelf ready to pronounce upon this Eſſay:

Tranſeat cum cæteris.

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aſh-coloured, rarely blue or greeniſh. According to the analyſis made by Bergman of this lava, it afforded 49 *per cent.* of *ſilex*, 35 of *argill*, 4 of pure *calcareous earth*, and 12 of *iron*. Another ſpecimen from the Lipari iſlands, afforded 69 of ſilex, 22 of *argill*, and 9 of iron. Theſe lavas melt very difficultly *per ſe*. The *black Agate of Iceland*, deſcribed in Sect. 438, called otherwiſe the *Lapis Obſidianus*, and *Piedra de Gallinaço*, mentioned in N° 21 of note [*d*] to pag. 916. is of this kind of lava, and has the ſame component parts.

The harder ſort of *pitch ſtone*, which gives fire with ſteel, belongs to this ſpecies. This ſtone is of a greyiſh, greeniſh, black, red, or brown colour; has a glaſſy appearance, of a ſemi-vitrified ſubſtances; and melts eaſily *per ſe*. It often contains heterogeneous ſubſtances. Its component parts are 65 *per cent.* of *ſilex*, 16 of *argil*, and 4 of *iron*; the 14 wanting parts were diſſipated in the analyſis made by Wiegleb, as Kirwan aſſerts.

The beds of lava are deepeſt and narroweſt in the proximity of the crater; and broader and ſhallower as they are more diſtant, unleſs ſome valley intervenes; *pumice-ſtone* and *aſhes* lie ſtill more diſtant. From theſe obſervations, ſays Kirwan, extinguiſhed volcanos are traced.

The Baſaltic mountains, which are very common in *Sweden*, ſeem to owe their origin to ſub-marine volcanos. *The Editor.*

DESCRIPTION

OF A

Mineralogical Pocket-Laboratory;

AND ESPECIALLY THE

USE OF THE BLOW-PIPE

IN

MINERALOGY,

BY GUSTV. VON ENGESTROM.

DESCRIPTION, &c.

§ 1. THAT Science which teaches us the properties of mineral bodies, and by which we learn how to characterize, diſtinguiſh, and claſs them into a proper order, is called *Mineralogy*. This, like all other ſciences, when rightly cultivated, and employed to its proper end (the Public Good), furniſhes us with many uſeful diſcoveries, in proportion as it increaſes.

§ 2. Though mineralogy has been ſtudied for ſeveral ages, yet its progreſs has been very ſlow.

Some learned men have, indeed, endeavoured to bring it into ſome ſyſtematical order; But as the paſſion for only collecting minerals and foſſils has ſtill predominated over that of enquiring into the nature of the ſubjects themſelves, they have for the moſt part met with but very little ſucceſs. Thoſe who were *mere Collectors*, being ſuperior in number to the *ſcientific men*, or *true Mineralogiſts*, and having more opportunities of getting new ſpecimens, were moſt of them not ſo communicative to the latter as they ought to have been. Some of theſe, were wholly taken up in gathering together

together immenſe heaps of things, ſeeming almoſt reſolved to get the whole of Nature into their cabinets, without having regard to any true order; while others, propoſing to correct this inconvenience, would pretend to ſome interior knowledge, as if that had been a conſequence of their collection; and by that fell into a ſtill greater extravagance.

All this certainly hindered mineralogiſts from improving much in the ſcience; but, happily, thoſe times are paſt. The world is grown more reaſonable at preſent, and Mineralogy ſeems to be more and more encouraged.

The great utility of the mineral bodies already known, promiſes us a much greater advantage from the ſtudy of this ſcience, than the mere pleaſure of collecting. But, in order to come at this advantage, we ought to ſearch into the very principles of theſe bodies, that we may be certain of not deceiving ourſelves in our judgement concerning them.

§ 3. As the principal intention of cultivating Mineralogy is to diſcover the œconomical uſe of minerals, it is neceſſary to know every mineral body in regard to all its effects; and thence to determine the beſt uſe it might be put to. A Syſtem of Mineralogy thus founded on the effects of its ſubjects, muſt be more ſcientifical, ſince it always has in view that valuable point, *their application to Common Life.* And ſince it is natural to the human mind to adapt every thing to its own advantage

vantage as far as poſſible, ſuch a ſyſtem muſt be more generally received, and at the ſame time more eaſily underſtood, as it includes the mineral bodies in a leſs number of claſſes, orders, &c. by which the memory is not ſo much loaded, as if only their ſurfaces had been deſcribed.

§ 4. This being granted, let us conſider what difficulties are to be met with in examining mineral bodies. Theſe often reſemble one another in their external appearances, though their conſtituent parts are quite different, and conſequently make them uſeful in different ways. Moſt of them require alſo to be changed from their natural form, and even often diſſolved, before they can be made any uſe of. Their figure and colour, or, in ſhort, their ſurfaces, are therefore not ſolely to be depended upon; we muſt penetrate into them; and they muſt be decompounded according to the principles of chemiſtry.

§ 5. By examining the mineral kingdom in this manner, we may now and then find the ſubjects of our experiments (even if nearly the ſame) to differ in ſome of their effects, which is particularly owing to the difficulty of juſtly determining the degrees of fire employed; a difficulty not yet removed, but which, however, ought not to hinder us from going as far as poſſibly we can, ſince we find in practice, that ſuch obſtacles are often remedied by repeated experiments; and of theſe we never can make too many, if judiciouſly performed.

§ 6. This

§ 6. This method of ſtudying Mineralogy was adopted a conſiderable time ago: but Mr. Pott, at Berlin, has brought it to a greater perfection: and after him Mr. Cronſtedt, in Sweden, extended it yet farther, ſubmitting every mineral body, that came into his poſſeſſion, to chemical experiments; in conſequence of which he afterwards publiſhed his *Eſſay towards a Syſtem of Mineralogy.*

§ 7. Thus the greateſt obſtacle is removed; the beſt method to learn Mineralogy is laid open, in following which we are enabled to render this Science more and more perfect. To obtain this end, chemical experiments are without doubt neceſſary; but as a great part of the mineral kingdom has already been examined in this manner, we do not want to repeat all thoſe experiments in their whole extent, unleſs ſome new and particular phœnomena ſhould diſcover themſelves in the things we are examining; for otherwiſe the tediouſneſs of thoſe proceſſes might diſcourage ſome from going farther, and take up much of the time of others, that might be better employed. An eaſier way may therefore be made uſe of, which even for the moſt part is ſufficient, and which, though made in miniature, is yet as ſcientifical as the common manner of proceeding in the laboratories; ſince it imitates that, and is founded upon the ſame principles. This conſiſts in *a method of making experiments upon a piece of charcoal with the concentrated flame of a candle urged by air from a Blow-*

pipe

pipe [*a*]. The heat occaſioned by this is very intenſe: and mineral bodies may be thus burned, calcined, melted, or ſcorified, &c. as well as in any great works.

§ 8. The Blow-pipe is in common uſe among jewellers, goldſmiths, glaſs-blowers, &c. and has even been uſed a little by the chemiſts and mineralogiſts; but, to the beſt of my knowledge, Mr. Cronſtedt is the firſt who made ſuch an improvement in its uſe, as to employ it in examining all mineral bodies. This gentleman invented ſome other apparatus, neceſſary in making the experiments, to go with the Blow-pipe, which all together make a neat little caſe, that, for its facility of being carried in the pocket, particularly on travels, might be called a *Pocket-Laboratory*: and as neither the Pocket Laboratory, nor even the extenſive uſe of the Blow-pipe, is yet generally known, I think it will not be altogether uſeleſs, to give a deſcription of it.

§ 9. The Blow-pipe is repreſented in its true figure and ſize, Plate 1, letter Q. D. The globe *b. b.* is hollow, and made on purpoſe to condenſe the vapours, which are always accumulated in the Blow-pipe when it has been uſed ſome time: if this globe were not there, the

[*a*] The meaning would be more preciſe and intelligible, if it had been ſaid, that it is a *method of aſſaying, by the concentrated flame of a candle, urged by air from a blow pipe, very ſmall pieces of each aiſtinguiſhable component part* of any ore, ſupported upon *a piece of charcoal, or otherwiſe.* The Editor.

vapours would go directly with the wind out into the flame, and would thereby cool the aſſay.

The hole in the ſmall end *c*, through which the wind comes out, ought not to be larger than the ſize of the fineſt wire. This hole may now and then be ſtopped up with ſome ſmall obſtacle, which checks the force of the wind; one ought therefore to have a piece of the fineſt wire, to clear it with when required. And, in order to have this wire the better at hand, a ſmall quantity of it may be packed in an inſide corner of the caſe.

§ 10. In order to determine the moſt convenient proportions of this inſtrument, ſeveral Blow-pipes of different ſizes, both bigger and ſmaller, have been tried: The former have required too much wind, and the latter being too ſoon filled with the wind, have returned it back again upon the lungs. Both theſe circumſtances greatly impeded the experiments, and are perhaps even prejudicial to health. This ſize fig. 1, is found to anſwer beſt; and though the hole muſt be as ſmall as before mentioned (Sect. ix.) yet the ſides of the pipe at the point muſt not be thinner, nor the point narrower than here repreſented, elſe it will be too weak, and will not give ſo good a flame. It is alſo to be obſerved, that the canal throughout the pipe, but particularly the hole at the ſmall end, muſt be made very ſmooth,

ſmooth, ſo that there may be no inequalities in it; as the wind would elſe be divided, and conſequently the flame made double. The Blow-pipe is to be reckoned the beſt, through which the longeſt and moſt pointed flame from off a common-ſized candle can be formed. Theſe Blow-pipes are commonly made of braſs or ſilver. *See the* deſcription *and* uſe *of the* Blow-pipe *in the Appendix to this Treatiſe.*

§ 11. *This Section of the Author in the former Edition, conſiſted of a deſcription of the Articles contained in the* Pocket Laboratory. *But as all theſe articles are contained in the* Laboratory *deſcribed in the Appendix to this Treatiſe, together with others, which the compactneſs of the arrangement, and the experience of Bergman and other late Chemiſts have enabled the Editor to add to them; it was thought unneceſſary to reprint the preſent Section.* The Editor.

§ 12. Whenever any ſubſtance is to be tried, one muſt not begin immediately with the Blow-pipe; but ſome preliminary experiments ought to go before, by which thoſe in the fire may afterwards be directed. For inſtance, a ſtone is not always homogeneous, or of the ſame kind throughout, although it may appear to the eye to be ſo: The magnifying-glaſs is therefore neceſſary, to diſcover the heterogeneous particles, if there be any; and theſe ought to be ſeparated, and every part tried by itſelf, that the effects of two different things, examined together, may not be attributed

to one alone. This might happen, with ſome of the finer *micæ*, which are now and then found mixed with ſmall particles of quartz, ſcarcely to be perceived by the eye. The Trapp, (in German *Schwartzſtein*) is alſo ſometimes mixed with very fine particles of Feltſpar (*ſpatum ſcintillans*) or of Calcareous Spar, &c. After this experiment, the hardneſs of the ſtone in queſtion muſt be tried with the ſteel. The Flint and Garnets are commonly known to ſtrike fire with the ſteel; but there are alſo other ſtones, which, though very ſeldom, are found ſo hard as to ſtrike fire.

There is a kind of Trapp of that hardneſs, in which no particles of Feltſpar are to be ſeen. Coloured glaſſes reſemble true gems; but as they are very ſoft in proportion to theſe, they are eaſily diſcovered by the means of the file. The common quartz-cryſtals are harder than coloured glaſſes, but ſofter than the gems. The loadſtone diſcovers the preſence of iron, when it is not mixed in too ſmall a quantity in the ſtone, and often before the ſtone is roaſted. Some kinds of *Hæmatites*, and particularly the *Cæruleſcens*, greatly reſemble ſome other iron ores; but this diſtinguiſhes itſelf from them by a red colour, when pounded, the others giving a blackiſh powder, and ſo forth.

§ 13. To manage the Blow-pipe with eaſe requires ſome practice. A beginner blows generally too ſtrongly, which forces him to take

take breath very often, and then he draws the flame at the ſame time along into the Blow-pipe; this is troubleſome for himſelf, and the matter cools always a little at the ſame time. But more experienced perſons can breathe in through the noſe, and at the ſame time blow through the pipe, ſo as to keep up a conſtant flame from the candle. The whole art conſiſts in this, that while the air is inſpired through the noſtrils, that which is contained in the mouth, be forced out through the tube, by the muſcular compreſſion of the cheeks; ſo that the action of the noſe, lungs, and mouth, reſemble the action of bellows with double partitions. In this manner there is no need of blowing violently, but only with a moderate and equal force, and thus the breath can never fail the operator. The only inconvenience attending it is, that the lips grow weak or tired, after having continued to blow for a conſiderable time; but they ſoon recover their former ſtrength, by ceaſing to blow for ſome minutes [a].

§ 14. The candle uſed for this purpoſe (Sect. 7.) ought to be ſnuffed often, but ſo, that the top of the wick may retain ſome fat in it, becauſe the flame is not hot enough when the wick is almoſt burnt to aſhes; but

[a] The new form given to the mouth-piece of the improved tube, which has two oppoſite angular foldings on the outſide, fits the lips of the operator ſo well, as to require a very weak preſſure to blow through it. *The Editor.*

only the top muſt be ſnuffed off, becauſe a low wick gives too ſmall a flame. The blue flame is the hotteſt; this ought therefore to be forced out when a great heat is required, and only the point of the flame muſt be directed upon the ſubject which is to be aſſayed *.

§ 15. The piece of charcoal made uſe of in theſe experiments (§ 7.) muſt not be of a diſpoſition to crack. If this ſhould happen, it muſt gradually be heated until it does not crack any more, before any aſſay is made upon it. If this is not attended to, but the aſſay made immediately with a ſtrong flame, ſmall pieces of it will ſplit off in the face and eyes of the aſſayer, and often throw along with them the matter that was to be aſſayed. Charcoal which is too much burnt conſumes too quick during the experiment, leaving ſmall holes in it, wherein the matter to be tried may be loſt: And charcoal that is burnt too little, catches flame from the candle, burning by itſelf like a piece of wood, which likewiſe hinders the proceſs.

§ 16. Of thoſe things that are to be aſſayed, only a ſmall piece muſt be broken off for

* It is moſt cleanly and convenient, that the candle be made of wax, and the wick ſhould be thicker than ordinary. It's upper end muſt be bended (*ſee fig.* 20. *plate* 2.) towards the matter intended to be heated, and the ſtream of air muſt be directed along the ſurface of the bended part, ſo as not abſolutely to touch it. *The Editor.*

that

that purpoſe, not bigger than that the flame of the candle (§ 7. 14.) may be able to act upon it at once, if required; which is ſometimes neceſſary; for inſtance, when the matter rquires to be made red hot throughout. A piece of about an eighth part of an inch ſquare is reckoned of a moderate ſize, and fitteſt for experiments; ſeldom more, but rather leſs. This proportion is only mentioned as a direction in regard to the quantity, the figure being of no conſequence at all, a piece broken off from a ſtone ſeldom or never happening to be ſquare; but here it is to be obſerved, that the piece ought to be broke as thin as poſſible, at leaſt the edges. The advantage of this is eaſily ſeen, the fire having then more influence upon the ſubject, and the experiment being more quickly made. This is particularly neceſſary to be obſerved when ſuch ſtones are to be aſſayed, which although in ſome reſpects fuſible by themſelves, yet reſiſt the action of the fire conſiderably; becauſe they may by theſe means be brought into fuſion, at leaſt at their edges, which elſe would have been very difficult, if the piece had been thick.

§ 17. Some of the mineral bodies are very difficult to be kept ſteady upon the charcoal during the experiment, before they are made red hot; becauſe, as ſoon as the flame begins to act upon them, they ſplit aſunder with violence, and are diſperſed. Such often are thoſe

which are of a ſoft conſiſtence, or a particular figure, and which preſerve the ſame figure in however minute particles they are broke; for inſtance, the Calcareous Spar, the Sparry Gypſum, Sparry Fluor, White Sparry Lead-ore, the Potters Ore (*Galena teſſellata*), the Teſſellated Mock-lead or Blende, &c. even all the common fluors which have no determinate figure, and moſt of the *Mineræ metallorum calciformes cryſtalliſatæ* or *ſpatoſæ*. All theſe are not ſo compact as common hard ſtones; and therefore, when the flame is immediately urged upon them, the heat forces itſelf through and into their clefts or pores, and cauſes this violent expanſion and diſperſion. Many of the clays are likewiſe apt to crack in the fire, which may be for the moſt part aſcribed to the humidity, of which they always retain a portion. Beſides theſe enumerated, there may be found now and then other mineral bodies of the ſame nature; but it is, however, not ſo common.

The only way of preventing this inconvenience is, to heat the body as ſlowly as poſſible. It is beſt, firſt of all, to heat that place of the charcoal where the piece is intended to be put on, and afterwards lay it thereon; a little crackling will then enſue, but commonly of no great conſequence. After that, the flame is to be blown very ſlowly towards it, in the beginning not directly upon, but ſomewhat above it, and ſo approaching nearer and nearer with the flame until it becomes

comes red hot. This will do for the moſt part; but there are nevertheleſs ſome, which, notwithſtanding all theſe precautions, it is almoſt impoſſible to keep on the charcoal. Thus the Fluors are generally the moſt difficult; and as one of their principal characters is diſcovered by their effects in the fire *per ſe*, (§ 18. *f.*) they ought neceſſarily to be tried that way. To this purpoſe it is beſt to make a little hole in the charcoal to put the Fluor in, and then to put another piece of charcoal as a covering upon this, leaving only a ſmall opening for the flame to come in at, and to look at the proof. As this ſtone will nevertheleſs ſplit and fly about, a larger piece thereof than is before-mentioned (§ 16.) muſt be taken, in order to have at leaſt ſomething of it left.

But if the experiment is to be made upon a ſtone whoſe effects one does not want to ſee in the fire *per ſe*, but rather with fluxes, then a piece of it ought to be forced down into melted borax, (§ 23.) when always ſome part of it will remain in the borax, notwithſtanding the greateſt part may ſometimes fly away by cracking.

§ 18. As the ſtones undergo great alterations when expoſed to the fire by themſelves, whereby ſome of their characteriſticks, and often the moſt principal, are diſcovered, they ought firſt to be tried that way; obſerving what has been ſaid before, concerning the quantity of matter, direction of the fire, &c.

The

The following effects are generally the reſults of this experiment, viz.

a. Calcareous earth or ſtone, when it is pure, does not melt by itſelf, but becomes white and friable, ſo as to break freely between the fingers; and, if ſuffered to cool, and then mixed with water, it becomes hot, juſt like common quick-lime. As in theſe experiments only very ſmall pieces are uſed, (§ 16.) this laſt effect is beſt diſcovered by putting the proof on the outſide of the hand, with a drop of water to it, when inſtantly a very quick heat is felt on the ſkin. When the calcareous ſubſtance is mixed with the vitriolic acid, as in gypſum, or with a clay, as in marle, it commonly melts by itſelf; yet more or leſs difficultly in proportion to the differences of the mixtures. Gypſum produces generally a white, and marle a grey glaſs or ſlag. When there is any iron in it, as a white iron ore, it becomes dark, and ſometimes quite black, &c. [*a*].

b. The

[*a*] *Crude calcareous earth* effervesces in a ſmall degree with the alkali of Soda, but is hardly diſſolved. But if it be previouſly burned, it is neither divided nor apparently diminiſhed.

The former is diſſolved in crude borax with effervescence, the latter with the application of the ſame flux, ſcarcely emits any bubbles. The ſame phænomena offer themſelves with the microſcomic ſalt, but the effervescence appears rather greater. It is to be remarked, that the particle of calcareous earth is eaſily diſſolved, either in borax or the phoſphoric acid, and the ſpherules remain entirely pellucid, as mentioned in the note to pag. 18; but if the quantity or proportion

b. The Siliceæ never melt alone, but become generally more brittle after being burnt. Such of them as are coloured become colourleſs, and the ſooner when it does not ariſe from any contained metal; for inſtance, the Topazes, Amethiſts, &c. ſome of the precious ſtones, however, excepted. And ſuch as are mixed with a quantity of iron, grow dark in the fire, as ſome of the Jaſpers, &c.

c. Garnets melt always into a black flag, and ſometimes ſo eaſily that they may be brought into a round globule upon the charcoal.

d. The Argillaceæ, when pure, never melt, but become white and hard. The ſame effects follow when they are mixed with phlogiſton; for inſtance, the *Soap-rock* is eaſily cut with the knife; but, being burnt, it cuts glaſs, and would ſtrike fire with the ſteel, if as large a piece as is neceſſary for that purpoſe could be tried in this way. The *Soap-rocks* are ſometimes

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proportion added to the flux be made greater, till at length the flux becomes ſaturated, and the flame be then removed; that part which was held in ſolution merely through the heat is ſeparated, which clouds are firſt formed, and afterwards the globule becomes opake, but may be again rendered tranſparent by heat. This is perfectly conſentaneous to what happens in the *humid way*. For hot water being ſaturated with nitre or glauber's ſalt, depoſes upon cooling that quantity which it ſuſtained merely by the action of the extraordinary heat. If the melted pellucid globule, which, by refrigeration, would become opake, be quickly immerged in tallow, water, or any other warm fluid (for in cold fluids they often fly in pieces) ſo that it may harden a moment ſooner, it retains its tranſparency; the particles being as it were

ſometimes found of a dark brown and nearly black colour, but become for all that quite white in the fire, like a piece of China ware. However, care muſt be taken not to urge the flame from the top of the wick, there being for the moſt part a ſooty ſmoke, which commonly will darken all that it touches; and if this is not obſerved, a miſtake in the experiment might eaſily happen. But if it is mixed with iron, as it is ſometimes found, it does not ſo eaſily part with its dark colour. The Argillaceæ, when mixed with lime, melt by themſelves, as above-mentioned (*a*). When mixed with iron, as in the Boles, they grow dark or black; and if the iron is not in too great a quantity, they melt alone into a dark flag; the ſame happens, when they are mixed with iron

were fixed in that ſtate in which they form a maſs pervious to the light; a phænomenon which is highly deſerving of attention, and cannot be performed in a crucible.

Ponderous Earth, expoſed alone to the flame, becomes (like calcareous earth) cauſtic, ſoluble in water, and deprived of the faculty of effervеſcing with acids.

In the alkali of ſoda it effervеſces little, but is ſenſibly diminiſhed.

In borax it is diſſolved with a ſlight effervеſcence.

It is likewiſe diſſolved in the microſcomic ſalt, but with an ebullition ſomewhat greater.

The phænomena reſpecting ſaturation, which have been noted in calcareous earth, take place likewiſe in this and other ſubſtances.

Magneſia being ignited like the earths already mentioned, but much more eaſily, it loſes the aerial acid, and therefore produces no bubbles by being afterwards applied to acids. It becomes phoſphoric after calcination, according to M. Macquer and Lavoiſier. But it does not acquire ſolubility in water by this treatment.

In

iron and a little of the vitriolic acid, as in the common clay, &c. [*b*]. *e.* Mica

In the alkali of ſoda it efferveſces little, and is ſcarcely at all diminiſhed.

In borax it is diſſolved with efferveſcence.

In the microſcomic ſalt it is likewiſe diſſolved, but with a greater commotion. *Bergman. See* Note [*i*] *to page* 94.

[*b*] *Common clay* abounds with heterogeneous matters, and always contains at leaſt a portion of ſiliceous earth, the quantity of which is conſiderable, being commonly more than half the maſs; therefore, when it is required to be pure, it is neceſſary to make uſe of the earth of allum carefully waſhed.

Being ignited, it hardens at the ſame time that its dimenſions are contracted. It is capable of acquiring a flinty hardneſs by means of ignition.

In the alkali of ſoda it efferveſces a little, but is diſſolved in a very ſmall quantity.

Borax takes it up with ſome efferveſcence.

The microſcomic ſalt ſhews a more ſenſible ebullition.

Siliceous Earth. It is not fuſible alone. The alkali of ſoda diſſolves it with a vehement efferveſcence, and affords a pellucid glaſs, if the weight of the earth in ſolution exceeds that of the flux. This experiment, and every other in which the alkali is made uſe of, muſt be performed in the ſpoon.

Borax diſſolves it but ſlowly, and without efferveſcence.

The microſcomic ſalt very ſlowly, and without the leaſt ebullition, takes up a portion ſo ſmall, that it hardly ſeems to affect it.

Derivative Earths, which are infuſible alone.

The Diamond (ſometimes decrepitating, and always diminiſhing by a long continued fire), Pure Aſbeſtus †, Siliceous Hydrophanes, Porcelane Clay †, the Hyacinth, Jaſper, Pure Mica †, Quartz, the Ruby, the Sapphire, Flint, Steatite †, the Topaz.

N. B. Thoſe ſubſtances which are marked thus †, become hard in the fire.

Infuſible Earths which change their colour.

Bolar clays in general become black.

Calcareous earth vitiated with manganeſe, becomes black.

Calcareous earth, rendered black by a ſubtle bitumen, becomes white.

Some

e. Mica and Abeſtos become ſomewhat hard and brittle in the fire, and are more or leſs refractory, though they give ſome marks of fuſibility.

f. The Fluors diſcover one of their chief characteriſtics by giving a light, like Phoſphorus, in the dark, when they are ſlowly heated; but loſe this property, as well as their colour, as ſoon as they are made red hot. They commonly melt in the fire into a white opaque ſlag, though ſome of them not very eaſily.

g. Some ſorts of the Zeolites melt eaſily and foam in the fire, ſometimes nearly as much as Borax, and become a frothy ſlag, &c.

h. A great many of thoſe mineral bodies which are impregnated with iron, as the Boles, and ſome of the White Iron Ores, &c. as well as ſome of the other iron ores, viz. the Bloodſtone, are not attracted by the loadſtone before they have been thoroughly roaſted, &c.

A further digreſſion upon theſe effects is unneceſſary here, their enumeration belonging more properly to Mineralogy; it is ſufficient only to have mentioned the moſt common, in order the better to explain the experiments that are made with the Blow-pipe.

§ 19. After

Some gems either change their colour or loſe it. Such are the Chryſolite, the Topaz, and ſometimes the Sapphire.

Both the red and green Jaſper become white or greyiſh.

Green, black, and red, ſteatite, become white.

Earths fuſible alone without ebullition,

Aſbeſtus Martialis. Augites, or Aqua Marina †. Baſaltes, Fluor mineralis. Chryſolite †. Granite. Marle. Moſt ſpecimens of the Petroſilex. Ponderous Spar. Spathum pyromachum, or Feld Spar. The Emerald †. Trapp.

N. B.

§ 19. After the mineral bodies have been tried in the fire by themſelves, they ought to be heated with fluxes, to diſcover if they can be melted or not, and ſome other phænomena attending this operation. For this purpoſe three different kinds of ſalts are uſed as fluxes, viz. *Sal Sodæ*, *Borax*, *and Sal fuſible microcoſmicum.*

§ 20. The Sal Sodæ is a mineral alcali well known, prepared from the herb Kali or Salt-wort; this ſalt is however not much uſed in theſe ſmall experiments, its effects upon the charcoal rendering it, for the moſt part, unfit for it; becauſe, as ſoon as the flame begins to act upon it, it melts inſtantly, and is almoſt wholly abſorbed by the charcoal. When this ſalt is employed to make any experiment, but a very little quantity thereof is wanted at once, viz. about the cubical contents of an eighth part of an inch, more or leſs. This is laid upon the charcoal, and the flame blown on it with the Blow-pipe; but as this ſalt commonly is in form of a powder, it is neceſſary to go on very gently, that the force of the flame may not diſperſe the minute particles of the ſalt. As ſoon as it begins to melt it runs along on the charcoal, almoſt like melted

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N. B. Thoſe ſubſtances which are marked thus †, are very difficultly brought to exhibit any ſigns of fuſion.

Earths fuſible with ebullition.

Lithomarga, or Stone-marle. Schoerl. Zeolite. Tourmalin. *The Editor from* Bergman.

tallow,

tallow, and when cold, it is a glaſſy matter of an opaque dull colour ſpread on the coal. The moment it is melted, the matter which is to be tried ought to be put into it, becauſe otherwiſe the greateſt part of the ſalt will be ſoaked into the charcoal, and too little of it left for the intended purpoſe. The flame ought then to be directed on the matter itſelf; and if the ſalt ſpreads too much about, leaving the proof almoſt alone, it may be brought to it again by blowing the flame on its extremities, and directing it towards the ſubject of the experiment. In the aſſays made with this ſalt, it is true, we may find if the mineral bodies which are melted with it have been diſſolved by it or not; but we cannot tell with any certitude whether this is done haſtily and with force, or gently and ſlow; whether only a leſs or a greater part of the matter has been diſſolved; nor can it be well diſtinguiſhed if the matter has imparted any weak tincture to the flag; becauſe this ſalt always bubbles upon the charcoal during the experiment; nor is it clear when cool; ſo that ſcarcely any colour, except it be a very deep one, can be diſcovered, although it may ſometimes be coloured by the matter that has been tried [a].

§ 21.

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[a] *Earths entirely ſoluble in the alkali of Soda with effervescence.*

Agate. Calcedony. Carnelian. Turkey Stone † (*Cos Turcica*). Fluor Mineralis †. Onyx. Opal. Quartz. Common Flint. Ponderous Spar.

N. B.

§ 21. The other two ſalts, viz. Borax, and the Sal fuſible microcoſmicum, are very well adapted to theſe experiments, becauſe they may by the flame be brought to a clear uncoloured and tranſparent glaſs; and as they have no attraction to the charcoal, they keep themſelves always upon it in a round globular form. The Sal fuſibile microcoſmicum is very ſcarce, and perhaps not to be met with in the ſhops; it is made of urine: Mr. Margraff has given a full account of its preparation in the Memoirs of the Academy of Sciences at Berlin [*b*].

N. B. *Thoſe articles which are marked with a* †, *effervеſce very little.*

Earths diviſible in the alkali of Soda, with or without effervеſcence; but not entirely ſoluble.

Amianthus, Asbeſtus. Baſaltes. * Cryſolite †.

(*N. B.* The yellowiſh cryſtalline matter, *which fills up the interſtices of the* native Siberian iron, *exhibits the ſame properties, with reſpect to fire, as the cryſolite*).

Granate †. Hornblende. Jaſper. Marleſtone. Mica. The mineral of alum from Tolfa. Petroſilex. Aluminous ſlate and roof ſlate, from Helſingia. Emeralds. ſteatites. ſpatum pyromachum. Schoerl. Talc. Trapp. Trippel. Turmalin.

N. B. *Thoſe marked* † *do not effervеſce.*

Earths neither fuſible nor diviſible in the alkali of Soda.

Diamond. Hyacinth. Ruby. Sapphire. Topaz.

[*b*] *Earths ſoluble in Borax, with more or leſs effervеſcence.*

Fluor mineralis †. Marle. Mica †. The mineral of Alum from Tolfa. Aluminous Slate and Roof-ſlate from Helſingia †. Ponderous ſpar. Schoerl. Talc †. Tourmalin.

N. B. *Thoſe marked* † *effervеſce very little.*

§ 22. The quantity of theſe two ſalts required for an experiment is almoſt the ſame as

Earths ſoluble in Borax without effervescence.

Agate. Diamond. Amianthus. Aſbeſtus. Baſaltes. Calcedony. Cornelian. Chryſolite. Turcica. Granate. Hyacynth †. Jaſper. *Lapis ponderoſus.* Onyx. Opal. Petro ſilex. Quartz †. Ruby. Saphire. Common flint †. Steatite Spatum pyromachum. Trapp, Trippel, or Tripoli, Topaz. Zeolite. Silicious Hydrophanes.

N. B. *Thoſe marked* † *require a larger quantity of the ſalt, and a longer continuance of fire than the reſt.*

Earths ſoluble in the microſcomic ſalt, with more or leſs effervescence.

Baſaltes †. Turkey Stone ‡. Fluor mineralis †. Marle Mica. The mineral of alum from Tolfa. Schiſtus aluminaris; ſchiſtus tegularis from Helſingia †. Schoerl. Spathum ponderoſum. Turmalin †. *Lapis ponderoſus.*

N. B. *Thoſe marked* † *effervesce very little during ſolution.*

Earths ſoluble in the microſcomic ſalt, without viſible effervescence.

Agate. Diamond. Amianthus. Aſbeſtus. Calcedony. Cornelian. Chryſolite. Granate. Hyacinth. Jaſper. Onyx †. Opal. Petroſilex. Quartz †. Ruby. Saphire. common flint †. Emerald. Spathum pyromachum. Talc, Topaz, Trapp, Trippel. Zeolite, Hornblend. Siliceous Hydrophanes. Lithomarga. Steatites

N. B. *Thoſe marked* † *are more difficultly diſſolved than the others.*

Calcareous Earth, ponderous Spar, Gypſum, and other additaments, often aſſiſt the ſolution, as well in the microcoſmic ſalt, as in borax. To which it is neceſſary to add, that in order to obſerve the effervescence properly, the matter added to the flux ſhould be in the form of a ſmall particle rather than in fine powder; becauſe in this laſt there is always air between the particles, which being afterwards driven off by the heat, affords the appearance of a kind of effervescence. *The Editor from* Bergman.

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the Sal Sodæ (§ 20.); but as theſe ſalts are cryſtalliſed, and conſequently include a great deal of water, particularly the borax, their bulk is conſiderably reduced when melted, and therefore a little more of theſe may be taken than the before-mentioned quantity.

§ 23. Both theſe ſalts, (§ 21.) when expoſed to the flame of the Blow pipe, bubble very much and foam before they melt to a clear glaſs, but more eſpecially the borax, which for the moſt part depends on the water they contain. And as this would hinder the aſſayer from making due obſervations on the phænomena of the experiment, the ſalt which is to be uſed muſt firſt be brought to a clear glaſs (§ 21.) before it can ſerve as a flux; it muſt therefore be kept in the fire until it is become ſo tranſparent that the cracks in the charcoal may be ſeen through it. This done, whatſoever is to be tried, is put to it, and the fire continued.

§ 24. Here it is to be obſerved, that for the aſſays made with any of theſe two fluxes (§ 22.) on mineral bodies, no larger pieces of theſe muſt be taken, than that altogether they may keep a globular form upon the charcoal; becauſe it may then be better diſtinguiſhed in what manner the flux acts upon the matter during the experiment. If this is not obſerved, the flux, communicating itſelf with every point of the ſurface of the mineral body, ſpreads all over it, and keeps the form of this laſt, which commonly is flat, (§ 16.) and

by that means hinders the operator obſerving all the phænomena which may happen. Beſides, the flux being in too ſmall a quantity, in proportion to the body to be tried, is too weak to act with all its force upon it. The beſt proportion, therefore, is about a third part of the mineral body to the flux; and, as the quantity of the flux mentioned in § 20. 22. makes a globe of a due ſize, in regard to the greateſt heat that is poſſible to procure in theſe experiments; the ſize the mineral body propoſed in § 16. requires when it is to be tried in the fire by itſelf is too large on this occaſion, the third part of it being here almoſt ſufficient.

§ 25. The Sal Sodæ, as has been ſaid before, is not of much uſe in theſe experiments: nor has it any particular qualities in preference to the two laſt mentioned ſalts, except that it diſſolves the Zeolites eaſier than the Borax and the Sal fuſibile microcoſmicum.

This laſt mentioned ſalt ſhews almoſt the ſame effects in the fire as the borax, and differs from this in very few circumſtances, of which one of the moſt principal is, that, when melted with manganeſe, it becomes of a crimſon hue, inſtead of a jacinth colour, which borax takes.

This ſalt is, however, for its ſcarcity, ſtill very little in uſe, borax alone being that which is commonly uſed. Whenever a mineral body is melted with any of theſe two laſt mentioned ſalts, in the above deſcribed manner (§ 22.

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et ſeq.) it is eaſily ſeen whether it is quickly diſſolved, becauſe in that caſe an efferveſcence ariſes, which laſts till the whole is diſſoved; or whether this is ſlowly done, in which caſe few and ſmall bubbles only riſe from the matter. Likewiſe, if it cannot be diſſolved at all, becauſe then it is obſerved only to turn round in the flux, without the leaſt bubble, and the edges look as ſharp as they were before.

§ 26. In order further to illuſtrate what has been ſaid about theſe experiments, I will mention ſome inſtances out of the Mineralogy, concerning the effects of borax upon the mineral bodies, viz.

a. The calcareous ſubſtances, and all thoſe ſtones which contain any thing of lime in their compoſition, diſſolve readily and with efferveſcence in the borax. The efferveſcence is the more violent, the greater the portion of lime contained in the ſtone. This reaſon, however, is not the only one in the gypſum, becauſe both the conſtituents of this do readily mix with the borax, and therefore a greater efferveſcence ariſes in melting gypſum with the borax, than lime alone.

b. The Siliceæ do not diſſolve, unleſs ſome few, which contain a quantity of iron.

c. The Argillaceæ, when pure, are not acted upon by the borax; but when they are mixed with ſome heterogeneous bodies, they are diſſolved though very ſlowly; ſuch is for inſtance the *Stone Marrow*, the *Common Clay*, &c.

d, The Granateæ, Zeolites, and Trapp, diſſolve but ſlowly.

e. The Fluores, Aſbeſtinæ, and Micaceæ, diſſolve for the moſt part very eaſily, and ſo forth.

§ 27. Some of theſe bodies melt to a colourleſs tranſparent glaſs with the borax; for inſtance, the *Calcareous* Subſtances, when pure, the *Fluores*, ſome of the *Zeolites*, &c. Others tinge the borax with a green tranſparent colour; viz. the *Granateæ*, *Trapp*, ſome of the *Argillaceæ*, ſome of the *Micaceæ* and *Aſbeſtinæ*. This green has its original, partly from a ſmall portion of iron, which the *Granateæ* particularly contain, and partly from phlogiſton.

§ 28. The borax cannot diſſolve but a certain quantity of a mineral body proportional to its own. Of the calcareous kind it diſſolves a vaſt quantity, but turns at laſt, when too much has been added, from a clear tranſparent, to a white, opaque ſlag. When the quantity of the calcareous matter exceeds but little in proportion, the glaſs looks very clear as long as it remains hot; but as ſoon as it begins to cool, a white half opaque cloud is ſeen to ariſe from the bottom, which ſpreads over the third, half, or more of the glaſs globe, in proportion to the quantity of calcareous matter; but the glaſs or ſlag is nevertheleſs ſhining, and of a glaſſy texture when broke; if more of this matter be added, the cloud riſes quicker and is more opaque, and

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ſo by degrees till the ſlag becomes quite milk white. It is then no more of a ſhining, but rather dry appearance, on the ſurface; is very brittle, and of a grained texture, when broke.

§ 29. All that has been ſaid hitherto of experiments upon mineral bodies, relates only to the ſtones and earths. I am now proceeding to the metals and ores, in order to deſcribe the manner of examining theſe bodies, and particularly the management of the Blow-pipe, in theſe experiments. An exact knowledge and nice proceeding are ſo much the more neceſſary here, as the metals are often ſo diſguiſed in their ores, as to be very difficultly known by their external appearance, and liable ſometimes to be miſtaken one for the other: Some of the cobalt ores for inſtance, reſemble much the Pyrites Arſenicalis; there are alſo ſome iron and lead ores, which are nearly like one another, &c.

§ 30. As the ores generally conſiſt of metals mineraliſed with ſulphur or arſenic, or ſometimes both together; they ought firſt to be expoſed to the fire by themſelves, in order, not only to determine with which of theſe they are mineraliſed, but alſo to ſet them free from thoſe volatile mineraliſing bodies: Thus this ſerves inſtead of calcination, by which they are prepared for further aſſays.

§ 31. Here it muſt be obſerved, that, whenever any metal, or fuſible ore, is to be tried, a

little concavity muſt be made in that place of the charcoal where the matter is to be put; becauſe, as ſoon as it is melted, it forms itſelf into a globular figure, and might then roll from the charcoal, if its ſurface was plain; but when borax is put to it, this inconveniency is not ſo much to be feared.

§ 32. Whenever an ore is to be tried, a ſmall bit is broke off for that purpoſe, of ſuch a ſize as is directed in § 16: this bit is laid upon the charcoal, and the flame blown on it ſlowly. Then the ſulphur or arſenic begins to part from it in form of ſmoke; theſe are eaſily diſtinguiſhed from one another by their ſmell, that of ſulphur being ſufficiently known, and the arſenic ſmelling like garlick. The flame ought to be blown very gently as long as any ſmoke is ſeen to part from the ore, but, after that, the heat muſt be augmented by degrees, in order to make the calcination as perfect as poſſible. If the heat is applied very ſtrongly from the beginning upon an ore that contains much ſulphur or arſenic, the ore will preſently melt, and yet loſe very little of its mineraliſing bodies, by that means rendering the calcination very imperfect. It is however, impoſſible to calcine the ores in this manner to the utmoſt perfection, which is eaſily ſeen in the following inſtance, viz. in melting down a calcined Potter's ore with borax, it will be found to bubble upon the coal, which depends on the ſulphur which is ſtill left, the vitriolic acid of this uniting with the borax,

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and cauſing this motion. However, lead in its metallic form, melted in this manner, bubbles alone upon the charcoal, if any ſulphur remains in it. But, as the lead, as well as ſome of the other metals, may raiſe bubbles upon the charcoal, although they are quite free from the ſulphur, only by the flames being forced too violently on it, theſe phænomena ought not to be confounded with each other.

§ 33. The ores being thus calcined, the metals contained in them may be diſcovered, either by being melted alone, or with fluxes: when they ſhew themſelves, either in their pure metallic ſtate, or by tinging the ſlag with colour peculiar to each of them. In theſe experiments it is not to be expected that the quantity of metal contained in the ore ſhould be exactly determined; this muſt be done in larger laboratories. This cannot, however, be looked upon as any defect, ſince it is ſufficient for a mineralogiſt, only to find out what ſort of metal is contained in the ore. There is another circumſtance, which, I am ſorry to ſay, is a more real defect in our little laboratory, which is, that ſome ores are not at all able to be tried by it, in ſo ſmall an apparatus: for inſtance, the gold ore called *Pyrites aureus*, which conſiſts of gold, iron, and ſulphur. The greateſt quantity of gold, which this ore contains, is about one ounce, or one ounce and an half out of one hundred pounds of the ore, the reſt being iron and ſulphur; and

and as only a very ſmall bit is allowed for theſe experiments, (§ 16. 31.) the gold contained therein can hardly be diſcerned by the eye, even if it could be extracted; but it goes along with the iron in the ſlag, this laſt metal being in ſo large a quantity in proportion to the other, and both of them having an attraction for each other.

All the Blendes and Black jacks, which are mineral zink ores, containing zink, ſulphur, and iron, cannot be tried this way, becauſe they cannot be perfectly calcined; and beſides, the zink flies off, when the iron ſcorifies: neither can all thoſe Blendes, which contain ſilver or gold mineraliſed with them, be tried in this manner, which is particularly owing to the imperfect calcination; nor are the quickſilver ores fit for theſe experiments, the volatility of this ſemi-metal making it impoſſible to bring it out of the poorer ſort of ores *; and the rich ores, which ſweat out the quickſilver when kept cloſe in the hand, not wanting any of theſe aſſays, &c. Thoſe ores ought to be aſſayed in larger quantities, and even with ſuch other methods as cannot be applied upon a piece of charcoal.

§ 34. Some of the rich ſilver ores are eaſily tried: for inſtance, *Minera argenti vitrea*,

* A piece of gold being laid over the proof, to receive the fumes, readily diſcovers if it contains any quick-ſilver. And it is probable, that by ſimilar proceſſes we may alſo be enabled to diſcover with the Blow-pipe other of the volatile ſubſtances.

commonly

commonly called Silver-glaſs, which conſiſts only of ſilver and ſulphur. When this ore is expoſed to the flame, it melts inſtantly, and the ſulphur goes away in fume, leaving the ſilver pure upon the charcoal, in a globular form. If this ſilver ſhould happen to be of a dirty appearance, which often is the caſe, then it muſt be melted anew with a very little borax, and after it has been kept in fuſion for a minute or two, ſo as to be perfectly melted and red-hot, the proof is ſuffered to cool: it may then be taken off the coal: and being laid upon the ſteel-plate, (*Pl.* 1. *fig.* N.) the ſilver is ſeparated from the ſlag by one or two ſtrokes of the hammer (*Pl.* 1. *fig.* E.). Here the uſe of the braſs ring (*Pl.* 1. *fig.* H.) is manifeſt, for this ought firſt to be placed upon the plate, to hinder the proof from flying off by the violence of the ſtroke, which otherwiſe would happen. The ſilver is then found incloſed in the ſlag of a globular form, and quite ſhining, as if it was poliſhed. When a large quantity of ſilver is contained in a lead ore, viz. in a potter's ore, it can likewiſe be diſcovered through the uſe of the blow-pipe, of which more will be mentioned hereafter. (§. 39.)

§ 35. Tin may be melted out of the pure tin ores, in its metalllic ſtate. Some of theſe ores melt very eaſily, and yield their metal in quantity, if only expoſed to the fire by themſelves: but others are more refractory; and as theſe melt very ſlowly, the tin, which

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ſweats out in form of very ſmall globules, is inſtantly burnt to aſhes, before theſe globules have time to unite, in order to compoſe a larger globe, which, might be ſeen by the eye, is not ſo ſoon deſtroyed by the fire; it is therefore neceſſary to add a little borax to theſe from the beginning, and then to blow the flame violently at the proof. The borax does here preſerve the metal from being too ſoon calcined, and even contributes to the readier collecting of the ſmall metallic particles, which ſoon are ſeen to form themſelves into a globule of metallic tin at the bottom of the whole maſs, neareſt to the charcoal. As ſoon as ſo much of the metallic tin is produced, as is ſufficient to convince the operator of its preſence, the fire ought to be diſcontinued, though the whole of the ore is not yet melted; becauſe the whole of this kind of ore can be ſeldom or never reduced into metal by means of theſe experiments, a great proportion being always calcined: and if the fire is continued too long, perhaps even the metal already reduced may likewiſe be burnt to aſhes; for the tin is very ſoon deſtroyed from its metallic ſtate by the fire.

§ 36. Moſt part of the lead ores may be reduced to a metallic ſtate upon the charcoal. The *Mineræ Plumbi calciformes*, which are pure, are eaſily melted into lead; but ſuch of them, as are mixed with an *ochra ferri*, or any kind of earth, as Clay, Lime, &c. yield very little of lead, and even nothing at all, if the hetero-

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genea are combined in any large quantity: this happens even with the *Minera plumbi calciformis arſenico mixta.* Theſe, therefore, are not to be tried but in larger laboratories. However, every mineral body ſuſpected to contain any metallic ſubſtance may be tried by the blow-pipe, ſo as to give ſufficient proofs whether it contain any or not, by its effects being different from thoſe of the ſtones or earths, &c.

§ 37. The *Mineræ plumbi mineraliſatæ* leave the lead in a metallic form, if not too large a quantity of iron is mixed with it. For example, when a teſſellated or ſteel-grained lead ore is expoſed to the flame, its ſulphur, and even the arſenic, if there be any, begins to fume, and the ore itſelf immediately to melt into a globular form; the reſt of the ſulphur continues then to fly off, if the flame is blown ſlowly upon the maſs; but, on the contrary, very little of the ſulphur will go off, if the flame is forced violently on it: in this caſe, it rather happens that the lead itſelf crackles and diſſipates, throwing about very minute metallic particles. The ſulphur being driven out as much as poſſible, which is known by finding no ſulphureous vapour in ſmelling at the proof, the whole is ſuffered to cool, and then a globule of metallic lead will be left upon the coal. If any iron is contained in the lead ore, the lead, which is melted out of it, is not of a metallic ſhining, but rather of a black and uneven ſurface: a little borax muſt in this

this caſe be melted with it, and as ſoon as no bubble is ſeen to riſe any longer from the metal into the borax, the fire muſt be diſcontinued: when the maſs is grown cold, the iron will be found ſcorified with the borax, and the lead left pure, and of a ſhining colour.

§ 38. Borax does not ſcorify the lead in theſe ſmall experiments, when it is pure: if the flame is forced with a violence on it, a bubbling will enſue, reſembling that which is obſerved when borax diſſolves a body melted with it; but, when the fire ceaſes, the ſlag will be perfectly clear and tranſparent, and a quantity of very minute particles of lead will be ſeen ſpread about the borax, which have been torn off from the maſs during the bubbling.

§39. If ſuch a lead ore (§ 37.) is rich in ſilver, this laſt metal may likewiſe be diſcovered by this experiment; becauſe, as the lead is volatile, it may be forced off, and the ſilver remain. To effect this, the lead, which is melted out of the ore, muſt be kept in conſtant fuſion with a ſlow heat, that it may be conſumed. This end will be ſooner obtained, and the lead part quicker, if, during the fuſion, the wind through the blow-pipe is directed immediately, though not forcibly, upon the melted maſs itſelf, until it begins to cool, at which time the fire muſt be directed on it again. The lead, which is already in a volatiliſing ſtate, will by this artifice be driven out in form of a ſubtil ſmoke; and by thus continuing by turns to melt

melt the maſs, and then to blow off the lead, as has been ſaid, until no ſmoke is any longer perceived, the ſilver will at laſt be obtained pure. The ſame obſervation holds good here alſo, which was made about the gold, that, as none but very little bits of ores can be employed in theſe experiments, it will be difficult to extract the ſilver out of a poor ore; for ſome part of it will fly off, with the lead, and, what might be left, is too little to be diſcerned by the eye. The ſilver, which, by this means is obtained, is eaſily diſtinguiſhed from lead by the following external marks, viz. that it muſt be red-hot before it can be melted: it cools ſooner than lead: it has a ſilver colour; that is to ſay, brighter and whiter than lead: and is harder under the hammer. (§ 34.)

§ 40. The *Mineræ cupri calciformes* (at leaſt ſome of them) when not mixed with too much ſtone or earth, are eaſily reduced to copper with any flux; if the copper is found not to have its natural bright colour, it muſt be melted with a little borax which purifies it. Some of theſe ores do not at all diſcover their metal, if not immediately melted with borax; the heterogenea, contained in them, hindering the fuſion, before theſe are ſcorified by the flux.

§ 41. The grey Copper ores, which only conſiſt of copper and ſulphur, are tried almoſt in the ſame manner as above mentioned. (§ 40.) Being expoſed to the flame by themſelves, they will be found inſtantly to melt,

and part of their ſulphur to go off. The copper may afterwards be obtained in two ways; the one, by keeping the proof in fuſion for about a minute, and afterwards ſuffering it to cool; when it will be found to have a dark and uneven appearance externally, but which, after being broke, diſcovers the metallic copper of a globular form in its centre, ſurrounded with a regulus, which ſtill contains ſome ſulphur and a portion of the metal: the other, by being melted with borax, which laſt way ſometimes makes the metal appear ſooner.

§ 42. The *Mineræ cupri pyritaceæ*, containing copper, ſulphur, and iron, may be tried with the blow-pipe, if they are not too poor. In theſe experiments the ore ought to be calcined, and, after that, the iron ſcorified. For this purpoſe a bit of the ore muſt be expoſed to a ſlow flame, that as much of the ſulphur as poſſible may part from it before it is melted, becauſe the ore commonly melts very ſoon, and then the ſulphur is more difficultly driven off. After being melted, it muſt be kept in fuſion with a ſtrong fire for about a minute, that a great part of the iron may be calcined; and, after that, ſome borax muſt be added, which ſcorifies the iron, and turns with it to a black ſlag. If the ore is very rich, metallic copper will be had in the ſlag, after the ſcorification: if the ore is of a moderate richneſs, the copper will ſtill retain a little ſulphur, and ſometimes iron: the product will therefore be brittle, and muſt with great caution

tion be ſeparated from the ſlag, that it may not break into pieces: and if this product is afterwards treated in the ſame manner as before ſaid, in ſpeaking of the grey copper-ores (§ 41.), the metal will ſoon be produced. But, if the ore is poor, the product after the firſt ſcorification muſt be brought into fuſion, and afterwards melted with ſome freſh borax, in order to calcine and ſcorify the remaining portion of iron; after which it may be treated as mentioned in Sect 41. The copper will, in this laſt caſe, be found in a very ſmall globule.

§ 43. The copper is not very eaſily ſcorified with this apparatus, when it is melted together with borax; unleſs it has firſt been expoſed to the fire by itſelf for a while, in order to be calcined. When only a little of this metal is diſſolved, it inſtantly tinges the ſlag of a reddiſh brown colour, and moſtly opaque; but as ſoon as this ſlag is kept in fuſion for a little while, it becomes quite green and tranſparent: and thus the preſence of the copper may be diſcovered by the colour, when it is concealed in heterogeneous bodies, ſo as not to be diſcovered by any other experiment.

§ 44. If metallic copper is melted with borax by a ſlow fire, and only for a very little time, the glaſs, or ſlag, becomes of a fine tranſparent blue or violet colour, inclining more or leſs to the green; but this colour is not properly owing to the copper, but it may

rather be to its phlogiſton; becauſe the ſame colour is to be had in the ſame manner from iron: and theſe glaſſes, which are coloured with either of theſe two metals, ſoon loſe their colour, if expoſed to a ſtrong fire, in which they are made quite clear, and colourleſs. Beſides, if this glaſs, tinged blue with the copper, is again melted with more of this metal, it becomes of a good green colour, which for a long time keeps unchanged in the fire.

§ 45. The iron ores, when pure, can never be melted by themſelves, through the means of the blow-pipe alone, nor do they yield their metal, when melted with fluxes, becauſe they require too ſtrong a heat to be brought into fuſion; and, as both the ore and the metal itſelf very ſoon loſe the phlogiſton in the fire, and cannot be ſupplied with a ſufficient quantity from the charcoal, ſo likewiſe they are very ſoon calcined in the fire. This eaſy calcination is alſo the reaſon why the fluxes, for inſtance borax, readily ſcorify this ore, and even the metal itſelf. The iron loſes its phlogiſton in the fire ſooner than the copper, and is therefore eaſier ſcoriſied; and this is the principle on which the experiment mentioned in Sect. 42 is founded.

§ 46. The iron is, however, diſcovered without much difficulty, although it were mixed but in a very ſmall quantity with heterogeneous bodies. The ore, or thoſe bodies which

which contain any large quantity of the metal, are all attracted by the loadſtone, ſome without any previous calcination, and others without having being roaſted. When a clay is mixed with a little iron, it commonly melts by itſelf in the fire; but, if this metal is contained in a limeſtone, it does not promote the fuſion, but gives the ſtone a dark, and ſometimes a deep black colour, which always is the character of iron. A *Minera ferri calciformis pura cryſtalliſata*, is commonly of a red colour: This being expoſed to the flame, becomes quite black, and is then readily attracted by the loadſtone, which it was not before. Beſides theſe ſigns, the iron diſcovers itſelf, by tinging the ſlag of a green tranſparent colour, inclining to brown, when only a little of the metal is ſcorified; but as ſoon as any larger quantity thereof is diſſolved in the ſlag, this becomes firſt a blackiſh brown, and afterwards quite black and opaque.

§ 47. Biſmuth is known by its communicating a yellowiſh brown colour to borax: and arſenic by its volatility, and garlick ſmell. Antimony both in form of regulus and ore, is wholly volatile in the fire, when it is not mixed with any other metal (except arſenic), and is known by its particular ſmell; eaſier to be diſtinguiſhed, when once known, than deſcribed. When the ore of antimony is melted upon the charcoal, it bubbles conſtantly, during its volatiliſing.

§ 48. Zinc ores are not eaſily tried upon the coal (Sect. xxxiii.). But the regulus of zinc, expoſed to the fire upon the charcoal, burns with a beautiful blue flame, and forms itſelf almoſt inſtantly into white flowers, which are the common flowers of zinc.

§ 49. Cobalt is particularly remarkable for giving to the glaſs a blue colour, which is the zaffre or ſmalt. To produce this, a piece of cobalt ore muſt be calcined in the fire (Sect. 30. 31.) and afterwards melted with borax. As ſoon as the glaſs, during the fuſion, from being clear, ſeems to grow opaque, it is a ſign, that it is already tinged a little; the fire is then to be diſcontinued, and the operator muſt take hold with the nippers (Pl. 1. *fig.* R.) of a little of the glaſs, whilſt yet hot, and draw it out ſlowly in the beginning, but afterwards very quick, before it cools, whereby a thread of the coloured glaſs is procured, more or leſs thick, wherein the colour may eaſier be ſeen againſt the day or candle-light, than if it was left in a globular form. This thread melts eaſily, if only put in the flame of the candle, without the help of the blow-pipe.

If this glaſs is melted again with more of the cobalt, and kept in fuſion for a while, the colour becomes very deep; and thus the colour may be altered at pleaſure.

§ 50. When the cobalt ore is pure, or at leaſt contains but little iron, a cobalt regulus is almoſt inſtantly produced in the borax, during

ing the fuſion; but when it is mixed with a quantity of iron, this laſt metal ought firſt to be ſeparated, which is eaſily performed, ſince it ſcorifies ſooner than the cobalt; therefore, as long as the ſlag retains any brown or black colour Sect 49. it muſt be ſeparated, and melted again with freſh borax, until it ſhews the blue colour.

§ 51. Nickel is very ſeldom to be had, and as its ores are ſeldom free from mixtures of other metals, it is very difficultly tried with the blow-pipe. However, when this ſemi-metal is mixed with iron and cobalt, it is eaſily freed from theſe heterogeneous metals, and reduced to a pure nickel regulus by means of ſcorification with borax, in the ſame manner as is mentioned Sect I. becauſe both the iron and cobalt ſooner ſcorify than the nickel. The regulus of nickel itſelf is of a green colour, when calcined: it requires a pretty ſtrong fire before it melts, and tinges the borax with a hyacinth colour. Manganeſe gives the ſame colour to borax, but its other qualities are quite different, ſo as not to be confounded with the nickel [a].

§ 52.

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[a] *The habitudes of mineralized metals in the fire.* When metals are diſſolved in a natural menſtruum, eſpecially ſulphur, I call them mineralized. I am aware that many uſe the term mineralization in a very extended ſenſe, ſo that they apply it not only to thoſe conjunctions of metals eſpecially, of which arſenic is a part, but even to the mechanical implication of earths or ſtones. But if arſenic be reckoned a

§ 52. Thus I have briefly deſcribed the uſe of the Blow-pipe, and the method of employing

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mineralizing ſubſtance, it is obvious that we muſt, as a conſequence, allow of no native metals. For each of theſe are debaſed with ſome other metal. Gold, for example, with ſilver or copper, platina with iron, ſilver with gold or copper, and ſo of the reſt. If therefore metals can be mineralized by arſenic, why not by other metals?

Sulphurated metals may be freed from their ſulphur by a ſlight roaſting upon the charcoal, or at leaſt the greateſt part may be driven off. The mineral muſt not be fuſed, for the ſurface in that caſe becoming much leſs, the mineralizing matter is much longer in flying off.

The ſeveral volatile matters are known by their ſmell, fume, or cloudy tinge around them; and the fixed reſidues being fuſed by the help of the fluxes, their contents may be known partly by their colour, partly by the reduced particles, and laſtly by the precipitation they afford upon iron.

Mineralized Gold. Gold cannot be directly united with ſulphur; but they are found together in the form of golden pyrites by the mediation of iron, which is ſtrongly attractive of both. But this mineral contains the gold in ſo ſmall a quantity, that though it may be ſeparated by fuſion and ſcorification, yet as it ſcarcely exceeds $\frac{1}{1000}$ part of the weight of the particle examined by the blow-pipe, it may eaſily eſcape obſervation by being enveloped in the ſcoria.

Mineralized Silver. Sulphurated ſilver, or the vitreous ſilver ore, being fuſed on the charcoal, becomes deprived of its mineralizing matter without difficulty; ſo that a bright globule is often produced, which may be purified, if neceſſary, with borax. Copper, iron, or manganeſe, deprive ſilver of its ſulphur.

If arſenic be preſent, together with ſulphur, as in the red ore of ſilver, both may be driven off by a ſlight roaſting, and the regulus muſt then be entirely freed from heterogeneous matters by the help of borax.

A mixture of copper, ſulphur, arſenic, and ſilver, or the white ſilver ore, exhibits a globule, which is rendered impure by theſe metals.

Silver,

ploying it in the ſtudy of Mineralogy. Any gentleman, who is a lover of this ſcience, will,

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Silver, loaded with ſulphur and lead (galena), loſes its ſulphur by roaſting, after which the lead may be gradually deſtroyed by repeated fuſions and coolings, or it may be ſeparated in the cupel.

Mineralized Lead. Galena affords a diſtinct regulus on the charcoal, unleſs it be too much loaded with iron. The lead is precipitated by iron and copper.

Mineralized Copper. This mineral, which is termed the *cinereous*, or more improperly *the vitreous* ore of copper, being gently roaſted with care, and at laſt fuſed, exhibits a maſs, whoſe exterior cruſt is uſually contaminated with ſulphur, but whoſe interior part is pure copper, if the fuſion has been ſufficiently made. The roaſted maſs in general affords the regulus more ſpeedily by the addition of borax. Cupreous pyrites always abounds with iron: this, after a proper roaſting, being ſufficiently fuſed, affords a regulus of copper, if the ore be rich; but if poorer it requires frequent ſcorifications with borax. But if the maſs be fuſed together with borax upon iron, veſtiges of copper are precipitated, though very ſmall. The celebrated Galin has diſcovered, that if the flame be thrown ſuddenly and by intervals, on a calcined grain of copper ore, the metallic ſplendor appears on its ſurface at thoſe inſtants, which at other times is black.

Mineralized Iron. Sulphurated iron, commonly known by the name of pyrites, may be melted into a globule, which, at the beginning, is environed with a bluiſh flame. But becauſe the metal itſelf is eaſily deprived of its phlogiſton and ſcorified, it exhibits no regulus, either alone, or when treated with borax.

Mineralized Biſmuth. Biſmuth exhibits a blue flame when fuſed.

This ore of biſmuth fuſed with borax is diſtinctly precipitated by iron or manganeſe.

Mineralized Nickel. Sulphurated Nickel has not yet been found, without an addition of iron and arſenic. By roaſting and frequent fuſions with borax, the regulus is obtained, but ſcarcely, if ever, free from foreign matter.

will, by attending to the rules here laid down, be able in any eaſy manner to amuſe himſelf in diſcovering the properties of thoſe works of nature which the mineral kingdom furniſhes us with. The huſbandman may by its help find out what ſorts of ſtones, earths, ores,

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Mineralized Cobalt. What we have ſaid of Nickel is likewiſe true of ſulphurated cobalt. At leaſt it is never without iron, and ſeldom free from arſenic. The regulus may be obtained upon the charcoal, by the method juſt mentioned, but always vitiated by heterogeneous matters.

Mineralized Zinck. Though Zink refuſes any direct union with ſulphur, yet they are found joined in the ſame mineral, and that eſpecially by the mediation of iron. The mineral, which is called *Blende*, is without metallic ſplendor, melts by itſelf upon the coal, commonly tinging the flame after the manner of zink. It is diſſolved both in borax and the phoſphoric ſalt. That mineral of zinck, which poſſeſſes the metallic ſplendor has the ſame properties, but ſeems to melt or be diſſolved more eaſily. Both theſe leave a cloudineſs upon the charcoal.

Mercury, Arſenic, and Antimony. Mercury, arſenic, and antimony, are volatile in the ſtate of mineralization. The firſt is found in the form of cinnabar, which melts on the charcoal, exhibits a blue flame, and gradually exhales without having any reſidue.

Yellow Arſenic, expoſed to the exterior flame in ſuch a manner that it may neither melt nor fume, becomes red, but returns to its original yellowneſs when cool: if it be urged ſo as juſt to begin to melt, it acquires a redneſs which perſiſts even when cold; if a ſtronger fire be applied, it flies entirely away. Riſigal contains a ſomewhat greater portion of ſulphur, and therefore more eaſily melts, but it flies away totally like the other.

Crude Antimony upon the charcoal melts, fumes, is imbibed, and at laſt totally vaniſhes, except a cloudineſs about the ſpot it reſted on.

Platina and *Tin* are ſcarcely found ſulphurated in the bowels of the earth. *The Editor from* Bergman.

&c.

&c. there are on his eſtate, and to what œconomical uſes they may be employed. The Scientific Mineraliſt may, by examining into the properties and effects of the mineral bodies, diſcover the natural relation theſe bodies ſtand in to each other, and thereby furniſh himſelf with materials for eſtabliſhing a Mineral Syſtem, founded on ſuch principles as Nature herſelf has laid down in them; and this in his own ſtudy, without being forced to have recourſe to great laboratories, crucibles, furnaces, &c. which is attended with much trouble, and is the reaſon why ſo few can have an opportunity of gratifying their deſire of knowledge in this part of natural hiſtory. I ſhall now add ſome hints towards the improvements of this apparatus, leaving to the judicious practitioner the taſk of completing them.

§ 53. A great number of fluxes might, perhaps, be found out, whoſe effects on mineral bodies might be different from thoſe already in uſe, whereby more diſtinct characters of thoſe mineral bodies might be diſcovered, which now either ſhew ambiguous ones, or which it is almoſt impoſſible to try exactly with the Blow-pipe. Inſtead of the *ſal ſodæ*, ſome other ſalt might be diſcovered better adapted to theſe experiments. But it is very neceſſary not to make uſe of any other fluxes on the charcoal than ſuch as have no attraction to it: if they, at the ſame time, are clear and tranſparent, when melted, as the borax and the

ſal fuſibile microcoſmicum, it is ſtill better: however, the tranſparency and opacity are of no great conſequence, if a ſubſtance is eſſayed only in order to diſcover its fuſibility, without any attention to its colour; in which caſe, ſome metallic ſlag, perhaps, might be uſeful.

§ 54. When ſuch ores are to be reduced whoſe metals are very eaſily calcined, ſuch as tin, zinc, &c. it might perhaps be of ſervice to add ſome phlogiſton, ſince the charcoal cannot afford enough of it in the open fire of theſe eſſays: ſuch a phlogiſton might be hard reſin, or ſome ſuch body. The manner of melting the volatile metals out of their ores *per deſcenſum* might alſo, perhaps, be imitated; for inſtance, a hole might be made in the charcoal, wide above, and very narrow at the bottom; a little piece of the ore being then laid at the upper end of the hole, and covered with ſome very ſmall pieces of the charcoal, the flame muſt be directed on the top: the metal might, perhaps, by this method, run into the hole below, concealed from the violence of the fire, particularly if the ore is very fuſible, &c.

Several of my experiments have indeed induced me to believe the poſſibility of theſe improvements; but as I have not yet had an opportunity of bringing them to perfection, I will not deliver them as infallible: theſe hints are only communicated as an inducement to farther trials.

§ 55.

§ 55. The uſe of the Pocket Laboratory, as here deſcribed, is chiefly calculated for a travelling mineraliſt. But a perſon, who always reſides at one and the ſame place, may by ſome alteration make it more commodious to himſelf, and avoid the trouble of blowing with the mouth. For this purpoſe he may have the Blow-pipe go through a hole in a table, and fixed underneath to a ſmall pair of bellows with double bottoms, ſuch as ſome of the glaſs-blowers uſe, and then nothing more is required, than to move the bellows with the feet during the experiment; but in this caſe a lamp may be uſed inſtead of a candle. This method would be attended with a ſtill greater advantage, if there were many ſuch parts as *c c* fig. Q. *Pl.* 1. the opening of which were of different dimenſions: thoſe parts might by means of a ſcrew be faſtened to the main body of the Blow-pipe, and taken away at pleaſure. The advantage of having theſe nozzles, if I may be permitted to call them ſo, of different capacities at their ends, would be that of exciting a ſtronger or weaker heat as occaſion might require. It would only be neceſſary to obſerve, that in proportion as the opening of the pipe (nozzle) is enlarged, the quantity of the flame muſt be augmented by a thicker wick in the lamp, and the force of blowing encreaſed by means of weights laid on the bellows, a much intenſer heat would thus be produced by a pipe of a conſiderable opening at the end, by which the experiments muſt undoubtedly be carried

carried farther than with the common Blow-pipe.

§ 56. A traveller, who has ſeldom an opportunity of carrying many things along with him, may very well be contented with this Pocket-Laboratory, and its apparatus, which is ſufficient for moſt part of ſuch experiments as can be made on a journey. There are, however, other things very uſeful to have at hand on a journey, which ought to make a ſecond part of the Pocket-Laboratory, if the manner of travelling does not oppoſe it: this conſiſts of a little box including the different acids, and one or two matraſſes, in order to try the mineral bodies in liquid menſtrua, if required.

§ 57. Theſe acids are, the Acid of Nitre, of Vitriol, and of Common Salt. Moſt of the ſtones and earths are attacked, at leaſt in ſome degree, by the acids; but the calcareous are the eaſieſt of all to be diſſolved by them, which is accounted for by their calcareous properties. The acid of nitre is that which is moſt uſed in theſe experiments; it diſſolves the limeſtone, when pure, perfectly, with a violent efferveſcence, and the ſolution becomes clear: when the limeſtone enters into ſome other body, it is nevertheleſs diſcovered by this acid, through a greater or leſs efferveſcence in proportion to the quantity of the calcareous particles, unleſs there are ſo few as to be almoſt concealed from the acid by the heterogeneous ones. In this manner a calcareous body, which ſometimes nearly reſembles a ſili-

ceous

ceous or argillaceous one, may be known from theſe latter, without the help of the Blow-pipe, only by pouring one or two drops of this acid upon the ſubject; which is very convenient when there is no opportunity, nor time, of uſing this inſtrument.

§. 58. The Gypſa, which conſiſt of lime and the vitriolic acid, (§ 18. 12.) are not in the leaſt attacked by the acid of nitre, if they contain a ſufficient quantity of their own acid, becauſe the vitriolic acid has a ſtronger attraction to the lime, than the acid of nitre: but if the calcareous ſubſtance is not perfectly ſaturated with the acid of vitriol, then an effervescence ariſes with the acid of nitre, more or leſs in proportion to the want of the vitriolic acid. Theſe circumſtances are often very eſſential in diſtinguiſhing the *calcarea* and *gypſa* from one another.

§ 59. The acid of nitre is likewiſe neceſſary in trying the zeolites, of which ſome ſpecies have the ſingular effect to diſſolve with effervescence in the abovementioned acid; and within a quarter of an hour, or even ſometimes not until ſeveral hours after, to change the whole ſolution into a clear jelly, of ſo firm a conſiſtence, that the glaſs, wherein it is contained, may be reverſed, without its falling out.

§ 60. If any mineral body is tried in this menſtruum, and only a ſmall quantity is ſuſpected to be diſſolved, though it was impoſſible to diſtinguiſh it with the eye during the ſolution,

tion, it can be eaſily diſcovered by adding to it *ad ſaturitatem* a clear ſolution of the alcali, when the diſſolved part will be precipitated, and fall to the bottom. For this purpoſe the *ſal ſodæ* (§ 20.) may be very uſeful.

§ 61. The acid of nitre will ſuffice for making experiments upon ſtones and earths; but if the experiments are to be extended to the metals, the other two acids (§ 57.) are alſo neceſſary. As the acids are very corroſive, they muſt not be kept in the ordinary Pocket-Laboratory, already deſcribed, for fear of ſpoiling the other apparatus, if the ſtoppers ſhould happen not to fit exactly to the necks of the bottles, and any of the acid ſhould be ſpilt.

The Sections 62. *and* 63. *contained a deſcription of the humid apparatus of the author. They are omitted, becauſe a more extenſive and compact apparatus is deſcribed in the appendix.*

§ 64. Another inſtrument is likewiſe neceſſary to a complete Pocket-Laboratory, viz. a Waſhing-trough, in which the mineral bodies, and particularly the ores, may be ſeparated from each other, and from the adherent rock, by means of water.

This trough is very common in laboratories, and is uſed of different ſizes; but here only one is required of a moderate ſize, ſuch as twelve inches and a half long, three inches broad at the one end, and one inch and a half at the other end, ſloping down from the ſides and the broad end to the bottom, where it is three quarters of an inch deep: I have given a

figure of it in Plate 2. *fig.* 22*. of one *fourth* or *third* of the uſual ſize. It is commonly made of wood, which ought to be choſen ſmooth, hard, and compact, wherein are no pores in which the minute grains of the pounded matter may conceal themſelves.

It is to be obſerved, that if any ſuch matter is to be waſhed, as is ſuſpected to contain ſome native metal, ſuch as ſilver or gold; a trough ſhould be procured for this purpoſe, of a very ſhallow ſlope; becauſe the minute particles of the native metal have then more power to aſſemble together at the broad end, and ſeparate from the other matter.

§ 65. The management of this trough, or the manner of waſhing, which I ſuppoſe to be known before, conſiſts in this. That when the matter is mixed with about three or four times its quantity of water in the trough, this is kept very looſe between two fingers of the left hand, and ſome light ſtrokes given on its broad end with the right, that it may move backwards and forwards, by which means the heavieſt particles aſſemble at the broad and lower end, from which the lighter ones are to be ſeparated by inclining the trough and pouring a little water on them. By repeating this proceſs, all ſuch particles as are of the ſame gravity may be collected together, and ſeparate from thoſe of different gravity, provided they were before equally

* The trough which forms part of the apparatus deſcribed in the Appendix, is of much ſmaller dimenſions than here deſcribed.

pounded;

pounded: though ſuch as are of a clayey nature, are often very difficult to ſeparate from the reſt, which, however, is of no great conſequence to a ſkilful and experienced waſher. The waſhing proceſs is very neceſſary, as there are often rich ores, and even native metals, found concealed in earths and ſand in ſuch minute particles, as not to be diſcovered by any other means.

APPENDIX

APPENDIX THE FIRST.

A DESCRIPTION OF THE POCKET-LABORATORIES FOR ASSAYING MINERALS, BY THE EDITOR.

1ſt. *The Dry Laboratory.*

1. THE Pocket-Laboratories are ſo called on account of their ſize, which is about that of an octavo book, for the convenience of carriage by traveling mineralogiſts, either in the pocket, or in the portmanteau. They contain the chief implements and materials required for the immediate trial and examination of foſſil ſubſtances, whether recently obtained, or kept under erroneous denominations in various collections of Natural Hiſtory; a circumſtance that often happens through the unſkilfulneſs of the owners.

2. The great advantage of this kind of miniature eſſays is very obvious, and they are often much more advantageous, than experiments made at large in Chemical Laboratories. Mr. Engeſtrom has made ſeveral obſervations on this ſubject in the firſt ſections of his treatiſe, to which may be here added, that by this method ſuch phænomena are diſtinctly obſerved, as are neceſſarily loſt in the large proceſſes; for the aſſayer has under his eyes the progreſs of changes and tranſient phænomena cauſed by fire on every ſubſtance: which cannot be obſerved in a large furnace. Beſides this circumſtance, there are often ſpecimens ſo rare, and ſo much eſteemed by the owners, that the ſmalleſt pieces are not obtained but with difficulty, to determine their real contents; for as to their external appearances, no one can ever reaſonably depend on them [*a*].

3. The names of thoſe great Mineralogiſts, who have contrived and improved theſe travelling apparatus, need only be mentioned, to ſhew the decided advantages and great utility of ſuch eſſays: theſe are the famous Andreas Swab, who firſt applied the blow-pipe to the examination of minerals, as Bergman obſerves;

[*a*] The external appearances, configurations, colours, and conſiſtency of mineral bodies, are often promiſcuouſly affixed to various foſſils, and are of courſe ſo incapable of affording a knowlege of any individual ſubſtance of the foſſil kind, that I can hardly form a notion how any reflecting perſon, not led away by a diſpoſition for childiſh amuſement, could ever attempt to miſlead the public with a mineralogical ſyſtem, grounded on ſuch uncertain principles.

His

His celebrated ſcholar, our Author, Mr. Cronſtedt, and after him Rinman, Quiſt, Engeſtrom, Scheele, Gahn, and Bergman himſelf, all from Sweden, where the knowledge of mineralogy has been purſued with indefatigable zeal: and laſtly, the celebrated Mr. de Morveau of Dijon, who is now diſcloſing with the greateſt ſucceſs the abſtruſe receſſes of Modern Chemiſtry to the French nation.

4. The chief pieces and implements of the Pocket-Laboratories are repreſented in the two annexed plates. The firſt contains the whole *Dry Laboratory*, ſo called on account of its containing whatever is required to try all kinds of foſſils in the *dry way* by fire, without any of the *humid menſtruums*. It conſiſts of a box as large as an octavo book, lined with green velvet, and covered with black fiſh-ſkin. It is 8 $\frac{1}{4}$ inches long, 6 broad, and 1 $\frac{1}{2}$ inches deep, outſide meaſure. The inſide is divided into different compartments, by thin partitions, which are continued to the bottom, in order to contain ſome other implements under thoſe repreſented in the quadrangular figure C. F. N. of the firſt plate, that are ſeen on opening the box.

5. D and Q are the two pieces that form the *blow-pipe*, which is repreſented entire at the bottom of the plate, marked by the ſame letters. This very uſeful inſtrument has been conſiderably improved of late in England. The mouth-piece *aa* is made of ivory, to avoid the diſagreeable ſenſation of having a piece of

metal a long time between the teeth and lips, which, if not of ſilver or gold, may be very noxious to the operator, a circumſtance that has been hardly noticed before. The other improvements of this uſeful inſtrument are mentioned in the Note [*b*].

6. The

[*b*] It is rather extraordinary that the Blow-pipe has been conſiderably deficient in many reſpects, although it has been uſed from time immemorial by various artiſts, as *gold-ſmiths*, *jewellers*, *glaſs-blowers*, and many others; and even after having been adopted by many able and ingenious perſons for mineralogical experiments. It is no matter of what metal the blow-pipe is made: braſs is the moſt commonly uſed; but it may be made of *ſilver* or *gold*, according to the fancy of the owner, provided it poſſeſſes the good qualities required.

1. If the mouth piece *a a* be made of a round form, it cannot be held for any length of time between the teeth and lips, to blow through it, without ſtraining the muſcles of the mouth, which produces a painful ſenſation. It muſt therefore have ſuch an external figure, as to adapt itſelf accurately to the lateral angles of the lips, having a flattiſh oval form externally, with two oppoſite corners to fit thoſe internal angles of the mouth, when it is held between the lips, as may be ſeen in that repreſented in the figure at the bottom of plate I.

2. The ſmall globe *b b* is hollow, for receiving the moiſture of the breath, and muſt be compoſed of two hemiſpheres, exactly ſcrewing into one another in *b b*; the male-ſcrew is to be in the lower part, and ſoldered on the crooked part *Q*. of the tube *Q D*. at ſuch a diſtance, that the inſide end of the crooked tube be even with the edge of the hemiſphere, as repreſented by the pointed lines in the figure. But the upper hemiſphere is to be ſoldered at the end of the ſtraight tube *D*. By theſe means, the moiſture ariſing from the breath falls into the hollow of the lower hemiſphere, where it is collected round the upper inſide end of the crooked part *Q*, of the blow-pipe, without being apt to fall into it.

3. The

6. The ſtream of air that is impelled by the blow-pipe, as ſeen in fig. 3. plate II. upon the flame, muſt be conſtant and even; and muſt laſt as long as the experiment continues to require it. This labour will fatigue the lungs, unleſs an equable and uninterrupted inſpiration can at the ſame time be continued. To ſucceed in this operation without inconvenience, ſome labour and practice are neceſſary. The whole artifice, however, conſiſts in this, *viz.* that, while the air is inſpired through the noſtrils, that part which is contained in the mouth be augmented at each expiration, and conſtantly forced out through the blow-pipe by the muſcular compreſſion of the cheeks. The compariſon of this operation to that of a

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3. The ſmall nozles, or hollow conical tubes, adviſed by Meſſieurs Engeſtrom, Bergman, and others, are wrong in the principle; becauſe the wind that paſſes from the mouth through ſuch long cones, loſes its velocity by the lateral friction, as happens in hydraulic ſpouts, which, when formed in this manner, do never throw the fluid ſo far, as when the fluid paſſes through a hole of the ſame diameter, made in a thin plate of a little metallic cap that ſcrews at the end of the large pipe. It is on this account that the little cap *c* is employed, having a ſmall hole in the thin plate, which ſerves as a cover to it; and there are ſeveral of theſe little caps, with holes of ſmaller and larger ſizes, to be changed and applied, whenever a flame is required to be more or leſs ſtrong.

4. Another conveniency of theſe little caps is, that even in caſe any moiſture ſhould eſcape falling into the hemiſphere *b b*, and paſs along with the wind through the crooked pipe Q, it never can arrive at, nor obſtruct the little hole of the cap *c*, there being room enough under the hole in the inſide, where this moiſture muſt be ſtopped, till it is cleaned and wiped out.

double bellows is exactly true; but that of the ... in the air-pump, as ſome pretenders ... hinted, is quite abſurd.

7. Some perſons may find this operation conſiderably difficult; but frequent trials will eſtabliſh the habit, ſo that an uninterrupted ſtream of air can be emitted through the blow-pipe during one quarter of an hour, and even much longer, without any conſiderable fatigue, as I have experienced myſelf.

8. This ſtream of air is required to impel the flame upon the matter under examination. Too great a flame does not yield to the blaſt; and too ſmall a one produces a weak effect. A ſlender candle ſhould therefore be choſen, with a cotton wick. The burnt top muſt be cut off at ſuch a length, that the remainder may be bent a little to near a right angle, as it appears by *a b* fig. 20. pl. II; and the ſame is repreſented alſo by the flame of fig. 3. The orifice *i* of the blow-pipe is to be held above, and near this bent part, in a perpendicular poſition to the wick, and then the air muſt be as regularly expelled, as poſſible. See § 13. p. 932.

9. The flame being thus forced ſideways by the violence of the blaſt, exhibits two diſtinct appearances: the internal *e* (fig. 20. plate. II.) is conical, well defined, and of a blue colour; at the apex of this, the moſt violent degree of heat is excited: but the external flame *c d* is of a browniſh, vague, and undetermined hue, which is deprived of its phlogiſton by the ſurrounding atmoſphere, and produces a much

leſs

leſs heat at its extremity than the interior bluiſh flame. It is therefore the apex of this internal blue flame that muſt be directed to the ſubject which is required to be aſſayed; as it appears by *m* in fig. 2. pl. II.

10. But every aſſay is always to begin by the exterior flame, which muſt be firſt directed upon the maſs under examination: and when its efficacy is well known, then the interior blue flame is to be employed.

11. Particular care muſt be taken to obſerve, whether the matter *decrepitates*, *ſplits*, *ſwells*, *liquefies*, *boils*, *vegetates*, *changes colour*, *ſmokes*, is *inflamed*, becomes *oily* or *magnetic*, &c. See § 18. p. 937. and the Notes.

12. The piece expoſed to the flame ſhould ſcarcely ever exceed the bulk of a middle-ſized grain of pepper; but it ought never to be ſo ſmall as not to be capable of being taken up by the tongs or forceps marked R pl. I. If it be too large, a part of it is neceſſarily out of the focus, and muſt cool both the ſupport and the part immerſed in the blue apex of the flame, as is ſaid already at § 16. p. 934.

13. After the ore is roaſted, it is to be pounded upon the ſteel plate marked N. plate I. by the hammer E. the particles being prevented from being diſſipated by the ring H, within which the pieces to be broken are to be put.

14. A ſmall piece ſhould always be added ſeparately to each of the fluxes, concerning which it muſt be obſerved, whether it diſſolves

wholy, or only partially? whether this be effected with, or without efferveſcence? quickly, or ſlowly? whether the maſs be divided into powder, or gradually and externally corroded? what colour the glaſs is tinged by, whether opake or pellucid? as has been already obſerved.

15. *C.* repreſents a wax-candle to be lighted for theſe trials, as being the moſt cleanly, although any other candle of tallow, or an oil-lamp, and ſtill better a lamp with burning ſpirits of wine, may be made uſe of for the ſame purpoſe.

16. F. pl. I. is a round plate of braſs, with a prong *d* in the middle, to ſerve as a candleſtick to hold the candle C. It has various concentrical grooves, to hold the ſolid different reſults of the experiments apart from each other. The ſpace under the round plate C, which has the prong turned downwards, is filled by one or two ſmall pieces of charcoal for ſerving as ſupports in the trials.

17. The three phials A. B. M. contain the three fluxes that are fit for theſe experiments; *viz.* the microcoſmic or phoſphoric *acid* is contained in that marked M. It is an acid already deſcribed, Sect. 164, and is partly ſaturated with *mineral*, and partly with *volatil* alkali, and loaded beſides with much water, and a gelatinous fat. When expoſed to the flame, upon the charcoal, it burns and foams violently, with a continual crackling noiſe, until the water and volatil alkali have flown off.

off. Afterwards it is leſs agitated, ſending forth ſomewhat like black ſcoriæ, ariſing from the burnt gelatinous part. Theſe are ſoon diſpelled, and a pellucid ſphærula, encompaſſed by a fine green cloud, is exhibited, being occaſioned by the deflagration of the phoſphorus ariſing from the extraction of the acid by means of the inflammable matter.

The clear globule which remains, upon the removal of the flame, continues longer ſoft than that formed by the borax, and therefore is more fit for the addition of the matter to be diſſolved. The volatil alkali is ſoon expelled by the fire; therefore an exceſs of acid ariſes in what remains, which eaſily attracts moiſture in a cool place.

18. The mineral alkali in the phial A, called otherwiſe *Sal Sodæ*, and deſcribed in Sect. 170, if fuſed upon the charcoal, melts ſuperficially, with a cracking noiſe, penetrates the charcoal, and diſappears. It is on this account that it is employed in the ſilver-ſpoon, marked P. on the outſide of the Pl. I. but which is packed under D or E. If this ſpoon were made of gold, but of a ſmaller ſize, or of hammered platina, it would be more convenient.

19. This is one of the ſupports of the matters under examination; but a piece of charcoal cut in a form almoſt cubical, as repreſented in fig. 2. pl. II, is the moſt commonly uſed in many aſſays. Particles of ores that are very ſmall and light are eaſily

carried off by the blaſt of air. To prevent this accident, a ſmall cavity is to be hollowed in the charcoal, in which, being partly protected by another ſmaller piece of charcoal over it, they may be expoſed to the apex of the flame: and on ſome occaſions two pieces of charcoal are tied together with a binding-wire, that is packed up in the box near the hammer; and having made two hollows near the edges, a hard reducible ſubſtance may be there expoſed to the greateſt heat of the apex of the flame, as if it were in a reverbatory furnace. *See* § 18, *p.* 937, *of the preceeding* Treatiſe *of Mr. Engeſtrom.*

20. The phial marked B contains cryſtallized borax, already deſcribed Sect. 182. When expoſed to the flame upon the charcoal; at firſt it becomes opake, white, and wonderfully intumeſcent; throws out branches and various protuberances: but when the water is expelled, it is eaſily collected into a maſs, which, when well fuſed, yields a colourleſs bead, which retains its tranſparency even after cooling: ſee, however, note [*t*], p. 18. If calcined borax be employed, the clear ſphærula is more ſpeedily obtained. This is a neutral ſalt, and conſiſts of mineral alkali partially ſaturated with a peculiar acid, known by the name of *Sedative Salt* (Sect. 165): each of its principles is ſeparately fuſible, and each diſſolves a great number of other matters.

The habits of theſe ſalts, when expoſed to fire, being once known, it will be eaſy to underſtand

underſtand the differences occaſioned by different additions.

21. G is a ſmall link of hard ſteel, to try the hardneſs or ſoftneſs of mineral ſubſtances; and alſo to ſtrike fire for lighting the candle, when required.

22. K denotes two pieces of black flint, to ſerve as a touch-ſtone: for being rubbed with any metal; if it be gold, the marks will not be corroded by *aqua fortis*; and alſo to ſtrike fire, when neceſſary, with the link G.

23. I is an artificial load-ſtone, properly armed with iron for the better preſervation of its attractive power. It ſerves to diſcover the ferrugineous particles of any ore after it has been roaſted, and powdered on the little ſquare of ſteel N, within the ring H, Plate I, as mentioned N° 13.

24. L is a triple magnifier, which, differently combined, produces 7 magnifying powers, the better to diſtinguiſh the ſtructure and metallic parts of ores, and the minute particles of native gold, whenever they contain that metal.

25. R is a pair of tongs for the eaſy handling the ſmall pieces to be tried or examined; and to turn or take out from the melted fluxes the ſmall buttons, or reguline products of the proceſſes when hot.

26 S is a file, to try the hardneſs of ſtones and cryſtals, &c. This is put under the hammer E or elſewhere.

27. There are alſo put in the empty ſpaces, under the inſtruments, ſome pieces of dry aga-

ric or tinder, and ſmall bits or ſplinters of wood, tiped with brimſtone, to ſerve as matches for lighting the candle, and various other little articles of uſe in theſe experiments.

2d. THE HUMID LABORATORY, *viz.*

For performing Experiments in the *Humid Way.*

28. The caſe of this Laboratory is of the ſame form and dimenſions as that of the *Dry Laboratory*, the depth only excepted, which is double, in order that the phials may ſtand upright, without being expoſed to ſhake off their ſtoples. It has been thought quite unneceſſary to add a plate engraved with the figure of this Laboratory, ſince every one knows well what muſt be the form of ſuch a collection of phials put together. They contain the principal *acids*, *teſts*, *precipitants*, and *re-agents*, both for examining mineral bodies by the *humid way*, and for analyſing the various kinds of mineral waters. Thoſe with *acids* and *corroſive ſolutions* have not only ground ſtoples; but alſo an external cap to each, ground over the ſtople, and ſecured downwards by a bit of wax between both, in order to confine the corroſive and volatil fluids within. But thoſe which contain mild fluid liquors have not ſuch external caps: and thoſe with dry inoffenſive ſubſtances are only ſtopped with cork.

29. Beſides theſe phials, there are two ſmaller cylindrical ones, which ſerve to exhibit the changes of colour produced by ſome of the re-agents

re-agents in theſe analytical aſſays. There are alſo 2 or 3 ſmall matraſſes, to hold the ſubſtances with their ſolvents over the fire; a ſmall glaſs funnel, for pouring the fluids; a little porcelane mortar, with its peſtle; one or two crucibles of the ſame ſubſtance; a ſmall wooden trough, to waſh the ground ores; ſome glaſs ſticks to ſtir up the fluid mixtures; and finally, pieces of paper tinged *red*, *yellow*, and *blue*, by the tinctures of *Fernanbuc wood* (commonly called *Braſil wood*) *Turmeric*, and *Lakmus*, thickened with a little ſtarch.

30. The following liſt contains the names of the various *fluid teſts* and *re-agents* that are neceſſary for theſe aſſays; and each phial is noted with the ſame ordinal number of the liſt, being diſtinctly cut with a point of a diamond on the outſide ſurface of the phial. But their whole number being too large to be all contained in a ſmall box, every one may give the preference to thoſe he likes the beſt. They are the following:

1. Concentrated *vitriolic acid*, whoſe ſpecific gravity may be expreſſed in the outſide.
2. *Nitrous acid*, purified by the nitrous ſolution of ſilver.
3. Concentrated *marine acid*, with its ſpecific gravity.
4. *Marine acid* dephlogiſticated.
5. *Aqua Regia* for gold, viz. 2 Nit. and 1 Marine.
6. *Aqua Regia* for Platina, viz. half marine and half nitrous acid.

7. *Nitrous*

7. *Nitrous ſolution* of *ſilver.*
8. Nitrous ſolution of mercury, made in the cold.
9. Muriatic ſolution of Barytes.
10. Nitrous ſolution of *Lime.*
11. Muriatic ſolution of *Lime.*
12. *Mercury* in its metallic ſtate.
13. Corroſive ſublimate of *Mercury.*
14. White *arſenic.*
15. Nitrous ſolution of *ſilver.*
16. Nitrous ſolution of copper.
17. Acid of *Sugar.*
18. *Liquor probatorius vini.*
19. *Hepar Sulphuris.*
20. Oil of tartar *per deliquium.*
21. Salt of *Tartar.*
22. Cauſtic *vegetable alkali.*
23. *Pearl Aſhes.*
24. Soap-makers Ley.
25. Common ſalt.
26. Vitriolated *argilla* (*alum.*)
27. Vitriol of iron [Copperas.]
28. Nitrous ſolution of *ſilver.*
29. Acetous ſolution of lead.
30. Acetous ſolution of Barytes.
31. Phlogiſticated alkaly by the Pruſſian blue.
32. Lime-water.
33. Lime-water phlogiſticated by the Pruſſian blue.
34. Cauſtic volatil alkali.
35. Mild volatil alkali (dry.)
36 Rectified ſpirit (alcohol).
37. Æther.
38. Spirituous tincture of galls.

N. B.

N. B. *There are ſome other* TESTS *to be mentioned in the Note* [*].

31. The method of applying the above teſts of acids and re-agents may be ſeen in Bergman's Treatiſes of the *Analyſis of Waters*, and of aſſaying by the *humid way*; in Kirwan's *Elements of Mineralogy*, in the *Elements of Chemiſtry* of Dijon, in the *Memoirs* of the ſame Academy, in Fourcroy's Lectures of Chemiſtry, &c.

3d. DESCRIPTION OF THE LAMP-FURNACE.

For Experiments, by the Humid *and* Dry Way, *repreſented in* Plate the Second.

32. This very curious and uſeful tho' ſmall apparatus, is an improvement of that which was contrived by Mr. de Morveau, in conſequence of the information he received from his friend, the Preſident de Virly, who ſaw at Upſal how advantageouſly the late eminent Profeſſor Bergman availed himſelf of this convenience for many analytical proceſſes in miniature, by the uſe of very ſmall glaſs veſſels, about one inch diameter, and other implements of pro-

[*] The following *Teſts* are very fit alſo for theſe aſſays, viz. 39. Spirituous ſolution of ſoap; 40. Sirup of violets; 41. Tincture of Litmus (*Lakmus* in Swediſh); 42. Tincture of Braſil wood; 43. Tincture of turmeric (*terra emerita*); 44. Oil of olives; Oil of Linſeed; 46. Oil of Turpentine; 47. Eſſential ſalt of wild-ſorrel (*acetoſellæ* vel *Oxalidis*); 48. *Hepar Sulphuris*; 49. Sugar of Lead; 50. Solution of Alum.

portional

portional ſize, for performing various chemical operations. *See* the Dijon Memoirs *for* 1783, *part* 1, *p.* 171.

33. There can be no doubt but that whenever theſe proceſſes are properly conducted, though in miniature, the lamp-furnace will prove amply ſufficient to perform, in a few minutes, and with very little expence, the various *ſolutions*, *digeſtions*, and *diſtillations*, which otherwiſe would require large *veſſels*, *ſtills*, *retorts*, *reverberatory furnaces*, &c. to aſcertain the component parts of natural bodies, though it is not always ſufficient to aſcertain their reſpective quantities. In this laſt caſe operations muſt be performed in great laboratories, and on a large ſcale, at a conſiderable expence. But the ſubſtances are ſometimes too valuable, as for inſtance, when precious ſtones are examined, and of courſe the laſt way never can be attempted in ſuch caſes.

34. Theſe ſmall proceſſes have likewiſe another advantage before noticed which cannot be obtained in works at large. It conſiſts in one's being able to obſerve the gradual progreſs of each operation, of eaſily retarding, or urging it, as it may require; and of aſcertaining at pleaſure each ſtep of every experiment, together with the phænomena attending the ſame.

35. The lamp-furnace is mounted in a ſmall parallelogram of mahogany, about 6 inches long and 4 wide, marked *fig.* 5, in plate 2. This is kept ſteady over the edge of a common table, by means of the metallic clamp *ww*, which

which is fastened by the screw *x*. The pillar *rs* is screwed in a vertical position on the plate *s*, being about 10 inches high; the other is screwed to the opposite corner, marked *p k*, and is only 7 ½ inches long; both are composed of two halves, that screw at *tt*, to be easily packed up with all the implements in a case covered with black fish-skin, and lined with green velvet, like the other laboratory already described.

36. The lamp *k* fig. 3 is supported on the plate *f*, which has a ring *l* that runs in the column *p k* and may be fixed by its screw *l* at the required height. This lamp has 3 small pipes of different sizes to receive as many wicks of different thickness, and to be filled with spirit of wine. By a similar method, a piece of charcoal is mounted and supported by the pliers, or little forceps screwed to the arm *ac* fig. 1, which has all the motions requisite for being fixed by means of proper screws, at a proper distance from the flame of the wick *b*. The blow-pipe *fig.* 4. is, by a similar mechanism, mounted on the smaller column *pq*, at such a distance as to blow the flame *hi* to the piece of ore *m*, which is upon the charcoal *gf*.

36. Every thing being disposed in this manner, the operator blows through the mouth-piece of the blow-pipe, *fig.* 4, and remains with his hands free to make the changes and alterations he may think proper.

N. B. The large round cavity *e* in the middle of the parallelogram, *fig.* 5, is to receive

the lamp *k* fig. 3, when all the implements are packed up in their caſe of black fiſh-ſkin; and the cover of the lamp is repreſented by fig. 13.

37. But if the operator has the double bellows, *fig.* 14 and 15, he fixes them to the table by the braſs clamp *y*. He then unſcrews the blow-pipe at *zz*: joins the mouth *m* of the flexible tube to the hemiſphere *zz*, paſſing each orifice, through the leather tub *fig.* 12, and tying both ends with a waxed thin pack-thread. If he works with his foot on the pedal, the ſtring of which is ſeen hanging from the end of the bellows, fig. 15, (and is always up, on account of the weight *e*) then the air is abſorbed by the bellows fig. 15, from whence it is propelled by the motion of the foot on the pedal, to the bellow fig. 14, whoſe conſtant weight *r* drives it out through the flexible pipe *fig.* 11: it of courſe enters the curbed part *zzi* of the blow-pipe, and drives the flame on the piece *m* of the ore, that is to be examined upon the charcoal.

N. B. 1. This double bellows is packed up by itſelf in a mahogany caſe, about 9 inches long, 6 $\frac{1}{2}$ wide, and about 3 $\frac{1}{4}$ deep, outſide meaſure.

N. B. 2. The laſt blowing bellows, fig, 14, has an inſide valve, which opens, when the upper ſurface of it is at its greateſt height: in order to let the ſuperfluous air eſcape out, as it would otherwiſe iſſue with great velocity out of the tube *fig.* 11. and ſpoil the operation.

38. If

38. If the operator chuſes to apply the *vital* or *dephlogiſticated* air in his proceſs, let him fill the glaſs-jar *h. fig.* 17, with this air; and put it within the tub marked by *a b z e*, filled with water, faſtening the neck of the jar within by a croſs-board *ed*, which has a hole in it for that purpoſe; then introducing the two ends of the flexible hollow tube (fig. 16) both to the mouth of the jar, and to the hole of the bellows, *fig.* 15; he opens the hole *m* of the jar, that was ſtopped with the ſtople *n*; the column of the water paſſes in through *m* and forces up the *vital air*, which enters the bellows, and of courſe, by the alternative motion of the pedal, paſſes through the end of the blow-pipe, to urge the flame upon the piece of ore *m fig.* 2. on the charcoal *g* [*a*].

[*a*] But the *dephlogiſticated air* may be alſo received at the ſame time, that it is produced, by tying the pipe, *fig.* 16. to the mouth an earthen retort, or of ſuch a porcelain ware as that from Mr. Wedgwood's manufactory, or even of a glaſs retort well-coated, according to the method of Mr. Willis, deſcribed in the Tranſactions of the Society of Arts, vol. V. p. 96. This laſt conſiſts in diſſolving 2 ounces of borax in a pint of boiling water, and adding to the ſolution as much ſlacked lime as neceſſary to form a thin paſte: this glaſs retort is to be covered all over with it, by means of a painter's bruſh, and then ſuffered to dry. It muſt then be covered with a thin paſte made of *linſeed oil* and *ſlacked lime*, except the neck that enters into the receiver. In two or three days it will dry of itſelf; and the retort will then bear the greateſt fire, without cracking. Two ounces of good nitre, being urged in the retort, by a good fire on a chafing-diſh, will afford about 7 or 800 ounce-meaſures of dephlogiſticated air. See Prieſtley's Experiments on air, vol. III, (or VI.) of his Philoſ. Works, p. 295.

39. To make any other kind of chemical aſſays, the forceps of *fig.* 2, which ſupports the charcoal, is taken off, by unſcrewing the ſcrew *b*; the blow-pipe is alſo taken off, by looſening the ſcrew *n*; the hoop *fig.* 8, is put in its place, where the metallic baſin of *fig.* 19. is put filled with ſand: the piece of *fig.* 9. is ſet on the other pillar *rs fig.* 1, to hold the matraſs, fig. 18, upright or the receiver *fig.* 21, &c.

40. In the ſame manner the retort *fig.* 10, may be put in the ſand-bath inſtead of the matraſs, with its receiver fig. 21, which may be ſupported on a bit of cork or wood hollowed to its figure, and held by the plyers, inſtead of the charcoal *fig.* 2.

41. But if the operation is to be made in the naked fire, the neck of the retort *fig.* 10, being luted to the receiver, or balloon fig. 21, may be hanged by a little chain with its ring, over the flame, being ſuſpended from the piece of *fig.* 8 or 9, ſcrewed to either of the pillars as may be moſt convenient. Otherwiſe the receiver, fig. 21, may be ſupported by the round hoop of braſs, fig. 9 or 8 ſcrewed at a proper height to the pillar, *fig.* 1, tying round it ſome packthread, to defend the glaſs from the contact with the metallic ſupport.

42. The piece of *fig.* 6 may be ſcrewed by its collar and ſcrew *ef* to any of the pillars; carrying with it the retort and its receiver, at proper diſtances, higher or nearer to the lamp, according as the flame is more or leſs violent.

43. It

43. It eaſily may be conceived that theſe implements afford all ſorts of conveniences for making any kind of ſmall operations and aſſays in miniature, provided the operator pays a proper attention to the diſpoſition requiſite for each proceſs or operation.

44. Every glaſs retort, receiver, matraſs, baſin, ſmall funnels, &c. was made by the lamp-workers, that blow beads, thermometers, and other ſmall glaſs inſtruments. N. B. The little funnels and ſyphons, to take off the waſhings from the ſubſtance that has boiled over the fire, were not engraved in *plate* the *ſecond*, to avoid crowding it, and embarraſſing the attention of the reader. Their figures are, however, ſo well known, that this omiſſion cannot produce any embarraſſment to a perſon of the leaſt ingenuity.

45. It is directed at N° 36, that the lamp *k*. *fig*. 3, is to be filled with ſpirit of wine, becauſe it gives no diſagreeable ſmell, and does not produce any fuliginous and diſagreeable cruſt on the veſſels as oil does; moreover, the ſpirit gives a dry flame, without ſmoke, and ſtronger than oil; beſides the ſpots and diſagreeable conſequences this laſt cauſes, if ſplit, &c. Mr. de Morveau adds, that the expence of ſpirit is quite inconſiderable, and that he performed in 8 or 10 minutes, with this apparatus, various diſſolutions, evaporations, and other proceſſes, which otherwiſe would have taken more than 3 hours, with the expence only of two or three halfpence for

the ſpirit of wine, whilſt the fuel of charcoal would have coſt near 10 or 11 pence.

46. But a very important circumſtance is, as Morveau obſerves likewiſe, that many philoſophers do not apply themſelves to chemical operations, for want of opportunity of having a laboratory to perform them, it requiring a proper room, and ſuitable expences of many large furnaces, retorts, crucibles, and numerous other implements, &c. whilſt theſe miniature laboratories may in great meaſure afford the ſame advantages, at leaſt to that degree of ſatisfaction ſufficient to aſcertain the contents and products of any ſubſtance that is ſubjected to trial; for with this ſimple apparatus a man of ſome abilities may, without any embaraſſement, in a very ſhort time, and with little expence, perform ſuch diſtillations as require a reverbatory furnace; all ſorts of proceſſes, digeſtions, and evaporations, which require a regular ſand heat; he may vary his experiments or trials, and multiply them to a great number of various performances, draw up his concluſions, and reaſon upon them, without loſs of time, without the hindrance of long preparations to work at large. And even when ſuch large works are to be performed, he may obſerve beforehand various phænomena of ſome ſubſtances, which being known in time, would otherwiſe impede the proceſſes at large, or make them fail abſolutely; and all this without the riſk of a conſiderable loſs, and without expoſing himſelf to a great fire, &c.

47. The results will be rarely, if ever, equivocal, especially if the operator is a man possessed of natural sagacity, and well acquainted with the general properties of the natural substances already known. If he directs his attention to the phænomena that happen in his experiments; and endeavours to use the proper means to obtain the knowledge he aims at, in order to destroy common prejudices, or to confirm those ideas and judgements of the objects he is to try and examine with his own eyes: in such a case he may depend upon it that his labours, in the corner of his study or cabinet, will never be, without producing some knowledge; since they will at least serve to direct him in those operations at large, which may be required to complete the proposed object, &c. *The Editor.*

APPENDIX II.

Containing various particulars of useful information to Mineralogical Enquirers.

1. *The Analysis of Earths and Stones: by* Kirwan.

§ 1. The best general solvent for stones or earths seem to be *Aqua Regia*, composed of two parts *nitrous*, and one of the *marine acid.*

If the ſtone or earth effervesces ſtrongly with acids, no other preparation is requiſite than a ſeparation of ſuch parts as are viſibly heterogeneous, and pulverization; the ſolution is then eaſily performed in a digeſting heat, if requiſite. The undiſſolved reſiduum, if purely ſiliceous, will melt into a tranſparent glaſs with half its weight of *mineral alkali*; if not, it is ſtill compounded, and its ſoluble parts will yield to a reiterated digeſtion.

§. 2. If the ſtone does not effervesce, or eaſily diſſolve in acids, after pulverization and digeſtion, but leaves an inſoluble reſiduum evidently compounded, or but ſlightly altered, it will require to be pulverized and mixed with twice or thrice its weight of *mineral alkali*, and to be expoſed to a low red heat for one or two hours. Mica requires a mixture of four times its weight of *mineral alkali*; after which it is to be ſeparated from the alkali by lixiviation and filtration, waſhing it with diſtilled water until the water is abſolutely taſteleſs and precipitates no metallic ſolution.

§. 3. The powdered ſtone, thus edulcorated, is to be dried by heating it to redneſs, and then weighed, and 100 grains taken for ſubſequent experiments. It were better if ſtill more were uſed, but the analyſis would be more expenſive.

§ 4. The powder is next to be digeſted in 8 or 10 times its weight of *aqua regia*, in a boiling heat in a retort, to which a receiver is luted, and the digeſtion reiterated as long as any

any thing appears to be diſſolved by freſh portions of the acid. Mica was found to require 50 times its weight of *aqua regia* before it was entirely decompoſed, as the acid is ſo volatile as very ſoon to diſtill over. Oil of vitriol has the advantage of bearing a greater heat, diſſolving baroſelenite, and of acting more powerfully on argill than *aqua regia*; but a large retort muſt be uſed, for often towards the end it puffs and throws up the earth or ſtone, and carries it into the receiver; beſides, it does not ſufficiently act on calces of iron, if theſe be much dephlogiſticated. *Spirit of Nitre* affects them ſtill leſs: hence I often uſe oil of vitriol firſt, then what has been diſſolved I precipitate by a mild alkali; and re-diſſolve the precipitate in *aqua regia*. A perfect ſolution being thus effected, the reſiduum is to be well waſhed, and the waſhings added to the ſolution: the reſiduum, well dried and weighed, gives the weight of ſiliceous earth in the compound.

§. 5. The ſolution is next to be examined; which we will ſuppoſe to contain the four ſoluble earths, *calcareous*, *ponderous*, *magneſian*, and *argillaceous*, and alſo a *calx of iron*; it always contains an exceſs of acid, of which it is in great meaſure deprived for a conſiderable time, as both acids are very volatile: and indeed, of the *marine*, none remains but what is combined with the calx of iron, as the nitrous chaſes it from the earths. By getting rid of this exceſs of acid, leſs alkali will be required

for the preceding precipitation, and leſs aerial acid ſet looſe which would retain much of the precipitate by re-diſſolving it; the ſolution ſhould then be evaporated to about half a pint.

§ 6. The ſolution being thus prepared, it is uſual to precipitate the calx of iron from it by the *Pruſſian alkali*; but to this method there are two objections: 1ſt, That the *ponderous earth*, if any, would alſo be precipitated and confounded in the *Pruſſian blue*: and 2d, That this precipitation, beſides being exceeding ſlow, ſeldom fails of leaving ſome iron ſtill in the ſolution, as the exceſs of the *Pruſſian alkali* which muſt neceſſarily be added, to be certain that all the iron is precipitated, never fails to re-diſſolve a portion of the *Pruſſian blue* which thus remains in the liquor, and cannot be got rid of. Hence the beſt method is as follows: firſt, prepare the Pruſſian alkali after the manner of Mr. *Bergman*, by digeſting and boiling a pure alkaline ſolution over Pruſſian blue, until the alkali no longer effervesces with acids, nor precipitates a ſolution of nitrous ſelenite, or any other earth, except the barytes. I even make it a little ſtronger; for if it be barely ſaturated with the tinging matter, it ſoon ſpoils and precipitates other earths, the tinging matter evaporating. Next let it be examined how much of this alkali is neceſſary to precipitate one grain of *iron* from its ſolution in dilute *vitriolic* or *marine* acid, and mark this on the label of the bottle

bottle that contains the alkali. Now we come to the application

§ 7. The ſolution of the earths being weighed, take 100 grains of it, and on theſe gradually pour the Pruſſian alkali (a portion of which is alſo previouſly weighed) until all the *iron*, or *ponderous earth* and *iron*, is precipitated; the weight of the alkali uſed, gives that of the *iron* contained in 100 grains of the ſolution; and the quantity contained in 100 grains of the ſolution gives that contained in the whole ſolution by the rule of proportion, from which the ponderous earth, if any be found in ſubſequent experiments, is to be deducted.

§ 8. The quantity of iron being thus found, the remainder of the ſolution is to be precipitated by aërated mineral alkali, and then boiled for half an hour, to expel as much as poſſible of the fixed air; by this means the whole of its contents are precipitated, and nothing remains in ſolution, but cubic nitre and a little common ſalt; when the precipitate has ſettled after one or two days reſt, the liquor is to be poured off, and the laſt portions taken up with a glaſs ſyringe. Diſtilled water is then to be added to the precipitate and boiled over it, and afterwards poured off, and taken up until it comes off taſteleſs.

§ 9. The precipitate being ſufficiently dried, is to be re-diſſolved in nitrous acid twice, and evaporated to dryneſs, then calcined for one hour in a white heat, and laſtly treated with about ſix or eight times its weight of diſtilled vinegar,

vinegar, in a heat of about 60 degrees, for one or two hours; by this means the *ponderous*, *calcareous*, and *magneſian* earths, will be extracted and ſeparated from the argill and calx of iron, which will remain undiſſolved.

§ 10. Of this acetous ſolution 100 grains ſhould be taken and examined with the Pruſſian alkali: if any part be precipitated, it is ponderous earth, and by heating it to redneſs its weight may be known: or ſtill better by a previous experiment, determining the quantity requiſite to precipitate one grain of acetous baroſelenites, and by the rule of proportion the quantity of it in the whole ſolution may be found.

§ 11. The remainder of the acetous ſolution is to be evaporated to dryneſs, and heated white in a clean poliſhed iron crucible for two hours, then weighed and thrown into hot diſtilled water; the calcareous earth (if any) will be diſſolved in a ſufficient quantity of this water, of which an ounce can ſcarcely diſſolve one grain, ſo that frequent affuſions of hot water may be requiſite; the magneſia will remain undiſſolved, and is to be dried and weighed; its weight gives that of the pure calcareous earth, from which that of the ponderous (if any) is to be deducted; the lime water may alſo be precipitated by an aerated alkali.

§ 12. Laſtly the argill and calx of iron, which remained undiſſolved by the acetous acid, are to be heated ſlightly, to prevent their cohering

cohering and reiteratedly boiled in dephlogiſticated nitrous acid to dryneſs, and finally diſſolved in that acid, which will then take up only the argill, which may be precipitated, dried, and weighed; though indeed this troubleſome operation may be unneceſſary, as the weight of the martial part being known by the experiment with the Pruſſian alkali, that of the argill is known of courſe, when only the two remain. This is even better, as the calx always increaſes in weight by theſe operations.

§ 13. Beſides this general method, ſome others may be uſed in particular caſes. Thus *to diſcover a ſmall proportion of argill, or magneſia, in a ſolution of a large quantity of calcareous earth*, cauſtic volatile alkali may be applied, which will precipitate the argill or magneſia, if any be, but not the calcareous earth. Diſtilled vinegar, applied to the precipitate, will diſcover whether it be argill or magneſia.

§ 14. 2dly, *A minute portion of calcareous or ponderous earth, in a ſolution of argill or magneſia*, may be diſcovered by the vitriolic acid, which precipitates the calcareous and ponderous; the ſolution ſhould be dilute, elſe the argill alſo would be precipitated. If there be not an exceſs of acid, the ſaccharine acid is ſtill a nicer teſt of calcareous earth. 100 grains of gypſum contains about 32 of calcareous earth; 100 grains of baroſelenite contains 84 of ponderous earth; 100 grains of ſaccharine ſelenite contains

tains 45 of calcareous earth; the inſolubility of baroſelenite in 500 times its weight of boiling water ſufficiently diſtinguiſhes it. From theſe *data* the quantities are eaſily inveſtigated.

§ 15. 3dly, *A minute proportion of argill in a large quantity of magneſia* may be diſcovered either by precipitating the whole and treating it with diſtilled vinegar, or by heating the ſolution nearly to ebullition, and adding more aërated magneſia until the ſolution is perfectly neutral, which it never is when argill is contained in it, as this requires an exceſs of acid to keep it in ſolution. By this means the argill is precipitated in the ſtate of embryon alum which contains about half its weight of argill (or for greater exactneſs it may be decompoſed by boiling it in volatil alkali). After the precipitation, the ſolution ſhould be largely diluted, as the Epſom ſalt, which remained in ſolution while hot, would precipitate when cold, and mix with the embryon alum.

§ 16. 4thly, *A minute portion of magneſia in a large quantity of argill* is beſt ſeparated by precipitating the whole, and treating the precipitate with diſtilled vinegar.

§ 17. Laſtly, *Calcareous earth and Barytes* are ſeparated either by precipitating the barytes by the Pruſſian alkali, or the calcareous by a cauſtic fixed alkali, or by precipitating both with the vitriolic acid, and evaporating the ſolution to a ſmall compaſs, pouring off the liquor, and treating the dried precipitate with

500 times its weight of boiling water; what remains undiſſolved is baroſelenite.

II. *Deſcription of a new Inſtrument for finding* ſpecific gravities, *by* Nicholſon.

Since mineralogiſts often want to know the ſpecific gravity of various *ſtones*, and other *ores*, as well as of *fluid acids* and other liquors; a deſcription of a new inſtrument of this kind may be acceptable in this place, as it is very eaſy and portable. It was invented by Mr. W. Nicholſon, and is inſerted in the ſecond vol. of *Memoirs*, publiſhed by the *Philoſophical Society of Manchester*, in 1785, from whence the following extract may be ſufficient to form an idea of its advantages.

2. This inſtrument is repreſented by *fig.* 23, Plate 2, and it conſiſts in a thin hollow ball A. of copper, of the ſize of a common hen's egg, with a ſmall baſin *e*. like a funnel, ſupported by a thin wire *db*. on the top, and a ſmall baſin *gh*. at the bottom, which muſt be ſo heavy, that on loading the upper one *e* with 1000 grains (or half grains), when the inſtrument is immerſed in diſtilled water, its ſurface be exactly at *cc*. [*g*].

3. Suppoſe

(*g*) This ball muſt be turned in the lathe very thin, and be tight againſt water and air. On the top is a little ſhoulder *b* with ſuch a hole, as to receive pretty tight the body of

3. Suppoſe you want to know the ſpecific gravity of the body *x*, which muſt be of courſe leſs than 1000 *half grains*. On putting it in the upper baſin *e*, ſo many units, or half grains, muſt be added in the ſame baſin, as to make it ſink, until the ſurface of the water comes to the white circle of the ſtem. It is evident that the weight of *x* is equal to the remaining unities, after the additional weight in the baſin *e* is ſubſtracted from 1000; thus, for example, if there were added to *e* 280 unities; in this caſe the weight of *x* is 720: for + 1000 — 280 = 720 [*b*].

4. Now

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a common ſowing needle whoſe point and eye have been broken off; this is to have a viſible mark in the middle, for which purpoſe it is firſt rendered blue by heat; and by rubbing it with a thin plate of braſs croſsways, weted with oil and fine emery, a ſmall circle of the white metal will be there ſenſibly formed round it.

[*b*] *N. B.* 1. The water muſt be the ſame in every experiment, and muſt have the ſame temperature; the 60 degree of Fahrenheit, is the moſt convenient, as it is commonly found in a temperate room. A ſmall thermometer therefore muſt be always provided for the uſe of the inſtrument: 2. And if the inſtrument itſelf requires a greater or leſs number of grains to ſink it to the mark at any given temperature; it will ſerve at any time to ſhew whether the denſity of the water is the ſame of that of diſtilled water, &c. 3. Great care muſt alſo be taken that no bubble of air be ſticking to the body *x*, or to the under baſin during the experiment, or elſe the reſult will be erroneous. 4. The handling of every part muſt be made by a pair of dry tongs, ſuch as thoſe of fig. 7. 5. Finally, if the water cannot be had diſtilled, nor even rain water, which is nearly the ſame; then the body *x* that is kept with the inſtrument muſt be examined in this water, and a new body being alſo examined,

4. Now let x be put in the lower baſin gh, leaving the other unities as before in the baſin e; then add as many of the ſame unities to e, until the ſurface of the water be again at cc. This additional number ſhews exactly the quantity of water that is diſplaced by the body x. Suppoſe it to be 60 unities: divide now the whole weight ($=720$) by this known bulk of water equal to it, viz. 60, and the ſpecific gravity of x will be ſhown by the quotient; viz. $\frac{720}{60} = 12$: which denotes, that the body x is 12 times heavier than an equal bulk of diſtilled water.

5. As for aſcertaining the ſpecific gravities of *acids*, or other *fluid matters*, the ſame method, already explained in the Notes to pages 612 and 613, may be equally applied to this new inſtrument.

6. Or elſe, take a very ſmall glaſs phial, with a ground ſtopple, and aſcertain, when filled with water, its ſpecific gravity by the above method; afterwards fill it exactly with the *acid*, or *fluid ſubſtance*, and determine by the ſame method the ſpecific gravity of both; deduct that of the phial alone, from the ſecond laſtly aſcertained; and the remainder will be the ſpecific gravity of the *acid* or *fluid* you tried the laſt.

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examined, the reſpective ſpecific gravities forming a compound with the weight of each body, a proportional reſult may be found to determine the true ſpecific gravity of the new body relatively to diſtilled water. The obſervations in this note apply univerſally to all hydroſtatical experiments made with any inſtrument whatever.

III. *An eaſy and very accurate Method of making* ORIGINAL WEIGHTS. *By the* EDITOR.

7. A very great difficulty, for the above operations of finding ſpecific gravities, conſiſts in having a very exact ſet of weights. I have diſcovered a new method, which I publiſhed ſeven years ago in the *Journal de Phyſique*, for January 1781, page 43. It is the eaſieſt, the cheapeſt, and the moſt exact, of any that ever was practiſed before; notwithſtanding which, I often hear repeated complaints of experimental operators, who ſtill adhere to the old and tedious method, without taking notice of the new one. This laſt conſiſts on the following particulars.

8. *Firſt*, Let a pair of ſcales with a very nice beam be provided, within a lanthorn, with glaſs panes on every ſide, having two ſmall lateral doors that may be open, facing each of the ſcales. Theſe are the only openings to be uſed, the front one being always ſhut during the operations, on account of the breath of the operator, which otherwiſe would diſturb the balances. As to the qualities of the beam, the eſſential one is, that it be conſtantly true, and ſenſible to the ſmalleſt weight, every time it is tried; for there are many falſe or unſkilfully conſtructed beams, that often vary in giving the equipoiſe of the very ſame things. But as to the length of the arms, from the point

of

of ſuſpenſion, it is no matter whether they are accurately equal or not.

Each ſcale muſt have a looſe ſmall baſin very light, to convey the things and weights in every operation.

9. *Secondly*, Prepare a good quantity of equal *unities*, for which a good method will be given by and by. Take a piece of *tinſel*, which is the thineſt plate of *lattin* (or *latten foil*, as Watſon calls it), ſuch as the taſſel and button-maſters employ in their work, but this muſt not be varniſhed any ways; which may be eaſily known by wetting it with water, for it will then dilute the coloured ſubſtance of the iſinglaſs with which it was varniſhed. If ſo, let it lie in hot water about twenty minutes; then waſh and wipe it. *4thly*, Cut out twelve or more triangular pieces of the tinſel, beginning with a very ſmall one about the $\frac{1}{20}$ part of an inch, and increaſing the others little by little, till the largeſt is the ſize of an inch; and fold one of the corners of each upwards, that it may eaſily be taken up with the tongs of Fig. 7, Plate II. *5thly*, You ſhould be provided with a ſet of very ſmall punchers of ſteel, containing the ten numerical figures, from 0 to 9 incluſively. Theſe are ſold ready made at the tool-ſhops, and coſt only two or three ſhillings. *6thly*, Stamp your ſmaller triangle with No. 1. the ſecond in ſize with No. 2. and ſo on. This being done, cut a ſmall parallelogram a little heavier than your greater triangle, which you will mark with No. 13 or 15; and

cut others till they are the ſize of an inch, taking care to bend one corner of each.

10. Take afterwards a piece of the common lattin ſheet, which is conſiderably thicker than the tinſel, and do the ſame as before, beginning with a triangle a little heavier than the bigeſt parallelogram of tinſel, and marking it with the following numbers of 24 or 30, and ſo on as before. Afterwards do the ſame with braſs plate whoſe thickneſs may be afterwards increaſed as far as your beam will be able to bear without bending or ſpoiling its axis. Then ſhut up each ſet of weights ſeparately in ſmall caſes or boxes, and ſtamp upon the outſide of each the two extreme numbers (the higheſt and the loweſt) of the pieces or weights there contained, in order to know afterwards in what box are the weights you may want.

11. Take now a very thin wire of gilt ſilver or metal, ſuch as the fineſt employed by the wire-drawers, before it be flattened in the mill, for covering the ſilk threads; wind it up very cloſely upon two wires as thick as large pins, *viz.* about $\frac{1}{20}$ of an inch thick; then cut the whole cover of thin wire lengthways, with the point of a ſharp penknife, running it between the two thick wires, and collect all the ſmall oval rings to ſerve as ſo many *unities*, which you may keep in a ſmall box by themſelves; and the ſame muſt be done with each dozen of the triangles and parallelograms, according to their numeros, the firſt and laſt of which ſhould be marked on the outſide, to find it eaſily

eaſily when neceſſary, as was already obſerved in the laſt article.

12. *N. B.* You muſt form your unities of ſuch wire, that each be very ſenſibly felt by your own ſcales; otherwiſe your labour would be worth nothing; for you cannot go farther than the leaſt quantity of weight that your ſcales are able to indicate.

Now, as to the practical method of making the niceſt operations with weights, it conſiſts in making uſe only of the right-hand baſin, both for the things to be examined, and for the weights; employing the left-hand ſcale only for counterpoiſing each weight as follows.

13. Make your ſcales very even, by putting ſome bits of braſs or wire on the left-hand one, both having one ſmall movable baſin as above-ſaid. When the equilibrium is perfect, take with the tongs (fig. 7.) the right-hand baſin; put therein your ſmalleſt triangle No. 1, and putting it again in the ſame ſcale, counterpoiſe it in the left-hand with any ſmall bits of metal.

14. *N. B.* Try whether it is right, by adding one *unity* more, and taking off another afterwards: obſerving whether the beam moves on each ſide. This proof is the moſt eſſential of all. After this, take out the right-hand baſin, and the triangle: put in as many *rings* or unities (No. 11.) as will counterpoiſe the other ſcale on the left-hand; and try by the above method of *adding* and *ſubſtracting* one unity, that it is right.

After-

Afterwards the ſame muſt be obſerved with each weight. Form then a liſt of your weights in a ſheet of paper divided into three columns; the firſt on the left-hand intitled *Pieces*; the ſecond *Quantity*; and the third *Accuracy*. Fill up the firſt column with a continued ſeries of numbers from 1 to 100, or to ſuch other number as you pleaſe. Then write facing each number the total of *unities* anſwering to each piece marked with the ſame; and in the third column write the *unity*, which being added or ſubſtracted, makes the balance turn one way or other. By this laſt column it will appear how nice your weights are, and how delicate are your balances [*i*].

15. By this method you may uſe as many ſets of weights as to come to hundreds and more pounds, with this particular advantage, which no one elſe ever obtained before, *viz.* of having a thorough conviction that each of your ounces or pounds cannot be deficient within or beyond one of your unities, if to ſuch an accuracy you have carried your performance [*k*].

16.

[*i*] You are to employ, in each operation, the ſame pieces whoſe weight is already aſcertained, adding only three or four of your unities, mentioned No. 11; and by ſo doing you will have the certainty that each is exact to a leſs error than one of the ſaid unities, which is no more than $\frac{1}{10000}$ or $\frac{1}{3000}$ of a grain weight.

[*k*] This propoſition is ſelf-evident, and of courſe does not require any demonſtration. But it is proper to obſerve, to ſuch as are unacquainted with the ſubject, that very large weights cannot be aſcertained totally, with ſuch a nicety as is here mentioned. The only obſtacle, which indeed is inſuperable,

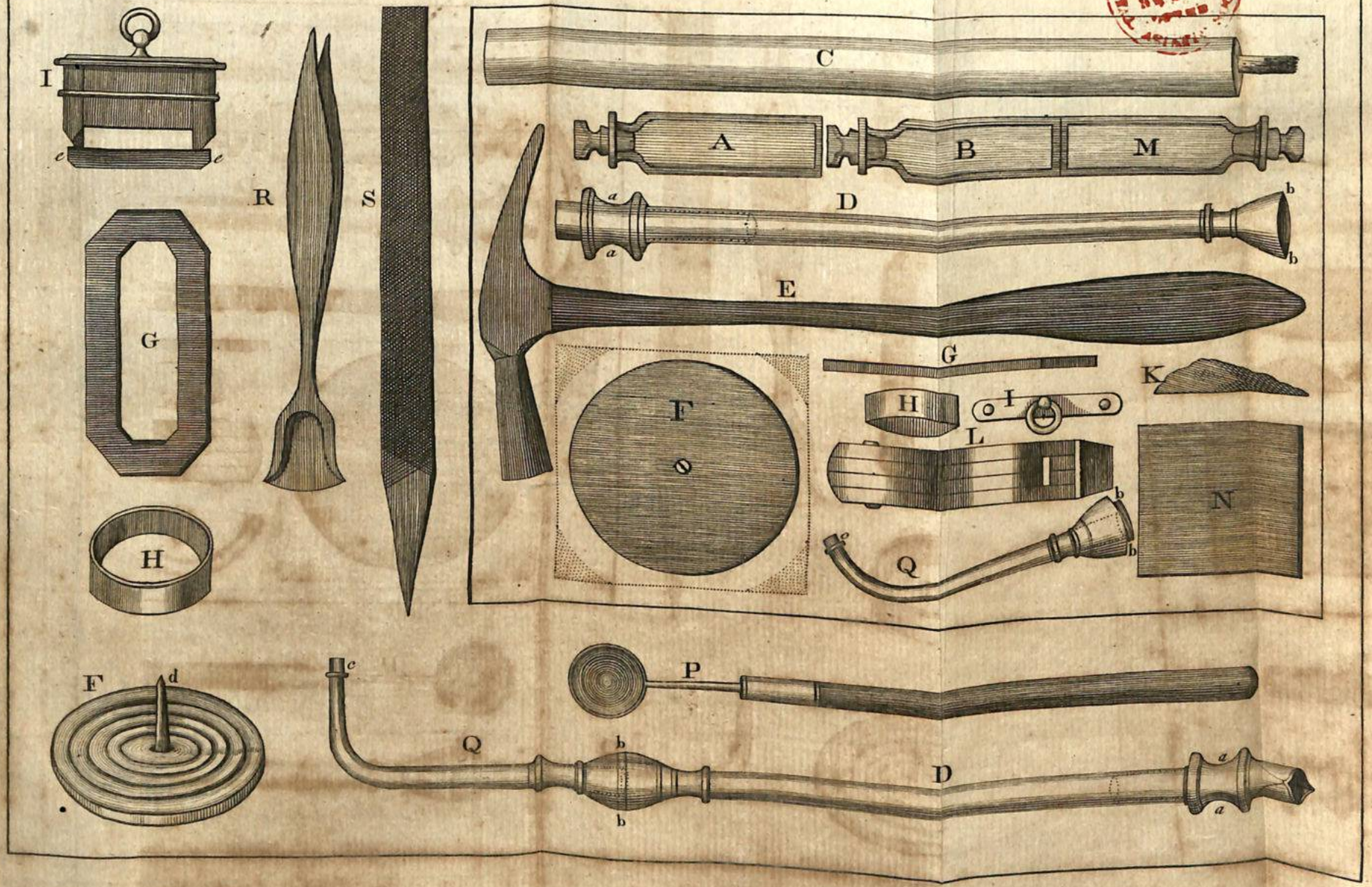
16. Laſtly, to know the relative weight of the Troy kind, get one of the moſt authentic *penny-weights* from the Mint in the Tower, or from the King's Aſſayer; weigh it with your weights, and you will immediately know how many of your unities make a penny-weight of England, or a *gros* of France, and ſo on of any other country whatever; ſo that by a ſimple calculation you will poſſeſs an original and univerſal ſcale for all kinds of weights.

THE EDITOR.

N. B. *All the above inſtruments*, viz. *the two* Pocket Laboratories, *the* Lamp-furnace, *the new inſtrument for* ſpecific gravities, *and the ſets of new weights, are ſold at moderate prices, by* William Brown, *Bookſeller, at the corner of* Eſſex-ſtreet, *in the* Strand, *near* Temple-Bar, London.

ſuperable, conſiſts in this, *viz.* that among all the known ſubſtances to which the human power can have recourſe, there are none ſo hard and unalterable as to form a beam, whoſe axis or points of ſuſpenſion, when loaded with the preſſure of *twice twelve ounces*, (two pounds weight,) ſhall not be ſo blunted or altered as to be incapable of yielding to the gravitating power of $\frac{1}{000}$ of a grain. From whence it is equally ſelf-evident, that no weight whatever can be aſcertained at once to a much greater accuracy than to the leaſt ſmall quantity, which being added or ſubſtracted, will cauſe ſome ſenſible difference in its perfect equilibrium.

THE END.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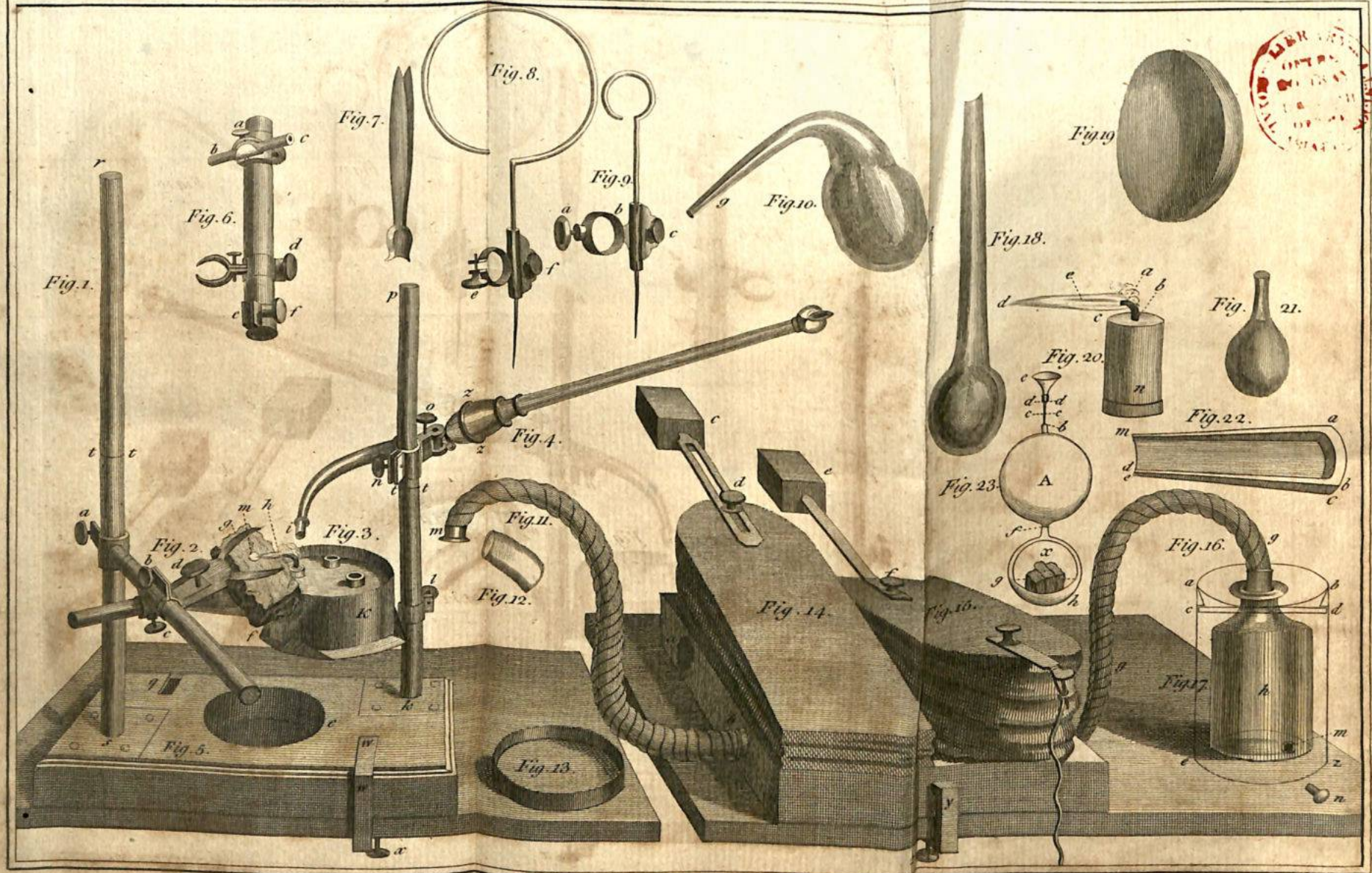
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Fig. 12.
Fig. 13.
Fig. 14.
Fig. 15.
Fig. 16.
Fig. 17.
Fig. 18.
Fig. 19.
Fig. 20.
Fig. 21.
Fig. 22.
Fig. 23.
A

AN ALPHABETICAL TABLE OF THE CONTENTS.

The Numbers indicate the Pages; the three Letters *a. b. c.* mean the *top*, *middle*, and *bottom* of each; and *n* means to be in the *Notes*.

A.

Acelsama terra, 20. *b.* n.
Achates, 186. *b. calceaoniſans*, 187. *b.*
Achates Iſlandicus, 917 *a.*
Acid Salts, their properties, 276. *a.*
———, their mutual converſion, by Count de Saluces, 286. *b.* 294. *b.* n.
Adamantine Spars. *See Additions* to p. 133.
Aerial acid, its properties, 320. *a.*
Aerated calx, 381.
——— iron, 406. *a.*
——— Magneſia, 388. *b.*
——— ponderous earth, 383. *a.*
——— (mild) volatil alkali, 374 *a.*
Æs corinthiacum, 785 *a.*
Æther's inflammable vapour, 447. *c.* n.
Agaricus mineralis, 20. *a.*
Agate, 186 *b.*
Agtſtein, 460. *a.*
Alabandicus lapis, 154. *a*
Alabaſter, 34. *b.*—Micaceous, 35. *a.*
Alabaſtrites, 35. *a.*
Albareſe, 77. *c.*
Alfwarſten, 71. *b.*
Alkaline earths, 19. *a.*
——— ſalts, 326. *a.*
——— vegetable, 329. *a.*
——— Mineral, 333. *a.*
Both *vegetable* and *mineral* alkalies exiſt in vegetable ſubſtances, before incineration, 344. *c.* n.
Alkali (mineral) from the Sea-ſalt, 336. *c.* n.
Alkali (*minerali*) with Magneſia, 420. *b.*
———, with ſuccineous acid, 421. *a.*

Alkali volatile 337. *a.*
Almandinus Ruby, 135. *b.* n.
Alumen (alum), 389. *a.*
Its properties, 394. *b.* n.
Obſervations on Allums, 394. *a.*
Native Allum with Sulphur, 423. *a.*
Aluminous vitriol of iron, 421. *c.*
Alum with vitriolated cobalt, 423. *c.*
Amandola marble, 81. *c.*
Amber, 421, *a.* Its properties, &c. 460. *a.*
Ambergris. Its properties, origin, &c. 457. *a.*
Ambra flava, 460. *a.*
Ambroix, (Pierre de St.) 83. *b.*
Ameſthyte, 151. *a.*
Amethyſte root, or mother of it, 152. *a.*
Amethyſte, 169. *b.*
Amethyſtizontas, 153. *b.*
Amiantus, 114. *a.*
Ammoniac (ſalt native), 372. *c.*
Ammoniacum (ſal) fixum, 17—39. *a.*
Amygdalites, or *Amygdaloides*, 884. *a.*
Analyſis of earths and ſtones, how . . . ? 999. *c.*
Androdamas, 183. *b.*
Antimony, 790. *a.* Native, 793. *a.* Calciform, 795. *a.* Its varieties, 797. n.
Mineralized, *ibid.* and 799. *a.*
Red antimony ore, 798. *a.* Obſervations on it, 801. *a.* *Pilulæ perpetuæ* of Antimony, i. e. that never loſe their purgative power by paſſing through the organs of digeſtion, 803. *b.* n. It is often poiſonous, 805. *b.* n.
Aphronatron, or *Aphronitrum*, 368. *c.* 418. *a.* n.
Aqua marina, 145. *a.*
Arable land, obſervations on it, 53. *c.*
The beſt compound, 55. *a.* n.
Argentum vivum, 577. *a.*
Argilla (common), plaſtica, 254. *c.* 941. *b.* n.
The *pure Argilla* is the baſe of Allum, 282. *c.* n.
Argilla aërata, 231. *Intumeſcens*, 255. *c.*
Argilla ammoniaca, viz. with volatil alkali (ammoniac of Argill), 399. *a.*
Argilla ſalita (Muriate of Argilla), 398. *b.*
Argillaceous earth, 226. *a.* Its properties, *ibid.*
Argillaceous fiſſile ſtones, 256. *c.*
Armenus (Lapis), 60. *c.*
Aſbeſtus, 113. *b.* Membranaceous, 114. *b.* *Suber montanum*, 115. *a.* Byſus, 115. *b.* Obſervations on Aſbeſtus, 116. *b.* Cloth made of it, 117. *c.* n. Aſbeſtus of 13 ſorts analyſed, 118.
Aſhdrawer, 154. *b.*
Aſkbly, 757. *a.*
Aſphaltum, 471. *c.* 505. *b.* n.
Attraction (polarity of) 429. *c.* n.
Aventurine,

Aventurine, 144. *b.* n.
Aurum fulminans, 530. *b.*
Aurum muſivum, 635. *a.*

B.

Ballance (new) for ſpecif. gravities, 1007. *a.*
Balaſs (rubi), 136. *a.*
Baldwin's phoſphorus, 17. *c.* n.
Ball-ore, 560. *b.*
Blatter ertz, 565. *b.*
Barbadoes-tar, 468. *a.*
Baro-ſelenite, 80. *a.* 88. *a.*
Barote, 84. *b.*
Barytes. *See* Ponderous earth.
——— *aerata*, 87. *a.* 383. *a.*
——— Muriatic, 382. *c.*
——— vitriolated, 382. *a.*
Baſaltes, 207. *c.* n. Its forms, *ibid.* Globulous, 913. *c.* n. Of various colours, 915. *c.* n. *Shoerls*, *ſpars*, *zeolithes*, *chryſolites*, &c. are found in them, 916, *b.* n.
Bathenſis (*calx*), 75. *b.* 20. *b.*
Beads, tranſparent and opake, 18. *b.* n.
Beleſoon, 455. *a.*
Bell-metal, 708. *c.*
Bergman improved his ſand, 55. *b.*
Bergblau, 60. *a.*
Berghartz, 471. *c.*
Bergmilch, 20. *c.* n.
Bergoel, 467. *a.*
Bergtheer, 468. *a.* 471. *c.*
Bergzunder, 565. *b.*
Bernſtein, 460. *a.*
Beryl, 145. *a.*
Bigia (*pietra*), 82. *b*
Bimſtein, 917. *c.* n.
Biſmuth. (*Biſmuthum*). Its properties, 757. *a.* 963. *c.* *Nativum*, 759. *b.* Calciform, 760. *b.* Mineralized, 761. *b.* *Ferro ſulphurato*, 762. *c.* With Arſenic, 763. *b.* Obſervations on Biſmuth, 764. *b.* Sympathetic ink of it, 768. *b.* n. Gives no blue colour to glaſs, 769. *c.* n.
Bitumens (obſervations on) 503. *a.*
Bituminous ſchiſtus, 479. *c.*
Blabeſt, 882. *b.*
Black-amber, 473. *c.*
Black-jack, 490. *b.* 779. *b.* n.
Black-lead. Its properties, 451. *a.* Its traces taken off by the *Indian rubber*, 454. *c.* n. Drawing pencils how made of it? 454. *c.* n. Its uſes, 455. *c.*
Black-mock-lead, 560. *c.*
Black wadd, 859. *b.* n.
Blank d'Eſpagne, 77. *b.*
Blende. *See* Zink, 769. *b.* Its principal varieties, 778. *b.* n. Phoſphorescent, 781. *b.* n.
Bley, 644. *a.* Bly, *ibid.*
Bleyglanz, 561. *a.* 660. *c.* n.
Bleyſchweif, 661. *a.*
Blow pipe (its uſe), 925. *a* Its deſcription, 929 *c.* Calcination of ores by it, 952. *Pyrites aureus* cannot be tried by it, 953. *b.* Zinc ores, 954. *b.* Silver, *ib. c.* Tin, 955. *c.* Lead-ores, 956. Copper-ores, 959. The *pyritaceæ*, 960. *b.*

Blue chalk, 77. *b.*
—— John, 40. *a.*
—— green, red, and yellow colours given by iron, &c. 163. *c.* n.
Blyertz, 451. *a.*
Bog-ores, 7. *c.*
Bolus, 238 *a.* *Armenus*, 239. *b.* *Induratus*, 241. *a.* *Squamoſus*, 242. *a*
Bones, their earth, 18 *b.* n.
Bononienſis (lapis), 88. *a.* *Spatum Bononiense*, 88. *b.*
Boracic acid. Its properties, 315. How made, 516. *c.* n.
Borax. Its properties, 362. *a.*
Bovey-coal, 482. *c.*
Braun-jord, 15 *a.*
Braſs, 707. *c.* n.
Braſs *ſee* Copper, 710. *c.* n.
Braſſica rubra, inſtead of *Litmus*, 277. *c.* n.
Braun Bleyertz, 781. *a.*
Breccia, 888. *a.* *Jaſpidea*, 890. *a.* *Silicea*, 890. *c.* *quartoiza*, 891. *a.* *Saxoſa*, 891. *b.* *Porphyrea*, ibid. *arenatea*, 892. *b.*
Briancon chalk, 98. *c.*
Brimſtone, 491. *a.*
Byſſus aſbeſtinus, 115. *b.*

C.

Cabōchon, what? 182. *b.* n.
Cacholong, 181. *c.* 182. *b.* n.
Cadmia botrites, 790. *b.* n.
Cadmia Fornacum, 789. *c.* n.
Caerulæum montanum, 60. *a.*
Calamine, 775. *a.*
Calamita bianca, 239. *c.* n.
Calcareous earth, 15. *a.*
Calcareous chalk, *idem* — Craie, *idem.*
Calcareous earth, pure, 20. *a.* Its affinities, 73. *a.* and following.
Its preperties, 938. *c.* n.
Its varieties, 56 and following; is the moſt diffuſed, 19. *b.*
Is the earth of animal bones, 19. *c.*
Sparry, 25. *c.* 76. 6. *b.*
Phlogiſticated, 48. *b.*
Pulveruenta, 58. *a.* *Rubra*, *ibid.*
With copper, 60. *a.*
With iron, 57. *b.*
Obſervations on calcareous earth, 62. *c.* 73 and 74.
Calcareous compounds, 50. *c.* and *following.* 80. and *following.*
Calcination of metals; and new doctrine of the ſame, 511. *c.* n.
Call, 208. *c.* n.
Calx Bathenſis, 75. *b.*
Calx nitrata, 378. *a.*
Calx muriatica, 380. *a.*
Calx acrata, 381. *a.*
Camehuya, 184. *b.*
Campan marble, 81. *a.*
Cannel-coal, 480. *a.*
Capnites, 790. *b.* n.
Carabé, 460. *a.*
Carbuncle, 135. *b.* n.
Carbunculus, *ibid.*
Carnelian, 185. *a.*
Carniolus, 185. *a.*
Carpolithi, 884. *c.* n.
Caryophylloides, 109. *c.*
Caſſius, his powder, 623. *c.* n.

Cat's-

Cat's-eye, 177. *c.*—183. *b.*
Cauk, 84. *a.*
Cementing iron ores, 734. *a.*
Ceruſa nativa, 61. *c.*
Ceruſa, how made? 648. *b.* n.
Chalcedony, 181. *b.*
Chalk-ſtone, 22. *b. idem granulatus*, 23. *b.*
Chalumeau (Terre à), 99. *b.*
Charcoal, what? 486. *a.*
Charcoal (the fitteſt for the Eſſays), 934. *b.*
Chatoiantes (pierres), 162. *c.* n.
Chert, 189. *c.*
Obſervations on Cherts, 190. *b.*
Chryſolite, 142. *b.*—145. *b.* n.
Chryſopraſe, 143. *c.* n.
Cinnabar, 593. *a.* The laſt in being revived, *ib. b.* n.
Cipolin marble, 82. *c.*
Circonciſion-ſtone, 176. *b.*
Clay, 227. *a.* Its properties, *ib.* & 941. *b.* n. For refining ſugar, 270. *b.* n.
Common plaſtic clay, 254. *c.* Its formation, 263. *a.* Obſervations on clays, 267. *a.*
Clay-marle, 54. *b.*
Coaks, 490. *b.*
Coaks (how made), 490. *b.* & *c.* n.
Coals (their origin), 486. *c.* n. Scotch coals, 489. *a.* Obſervations on foſſil coals, 485. *c.* Coal (ſlate), 479. *a.*
Cobalt. Its properties, 823. *a.* and 964. *b.* Native, 826. *a.* How manufactured, 834. *b.* n. Calciform, 828. *a.* With Nickel, 832. *b.* With Iron, 830. *c.* Combined with arſenical acid, 829. *c.* Its aſſay in ſmall quantities, 836 *c.* n. Obſervations on it, 832. *c.* Wrong and vulgar notions of cobalt, 837. *a.*
Cockle cryſtalliſed, 211. *a.*
Cockle ſpar, 148. *b.*
Cockles, 202. *b.*—207. *b.*
Colniſh clay, 234. *b.*
Colours of acids (ſucceſſion of): theſe are ſeen but by refracted rays, 278 *b.* n.
Colours, (various) ſhewn by iron with heat, 753. *c.* n.
Colours, (various) given to hard ſtones by iron, 163. *c.* n.—81. *b.*
Colours, their natural ſucceſſion, 278. *b. n.*
Columbina (pietra), 82. *a.*
Combuſtibles, what? 434. *b.* n. New doctrine, *ib.*
Combuſtion, 435. *b.* and *following.*
Combuſtion (the new doctrine of it), 492. *b.* n.
Contrefait, 784. *b.* n.
Copal, 464. *b.* n.
Copper. Its qualities, 671. *a.* Its thin leaves how gilt at at Nuremberg? 672. Native Copper, 678. *b.* Calciform Copper, 681. *a.* and 684. *a.* Red copper ore, 683. *a.* Cupreous ſtones, 685.

685. *b.* Mineralized, 687. *b.* Pyritous, 689. 692. 960. *b.* White copper ore, 693. *a.* with arſenic and zinc, 694. *b.* with vitriolic acid, 695. with muriatic acid, 696. Copper coal-ore, 698. *a.* Obſervations on copper, 698. *b.* Verdegris, 702. *b.* n. Is a poiſon. Poiſonous qualities of its veſſels in the kitchen, 703. *b.* n. and following.
Copper-ore of various colours, 688. *c.* n.
Copper of cementation, 695. good, how made? 706. *b* n. white copper, 710. *a.*
Copper, when melted, explodes by vapour, 675. *b.* n.,
Copperas-ſtone, 497. *a.*
Coral-ſtone, 186. *c.* n.
Coralina, (Oriental) 145. *c.* n.
Corium (ſive *caro*) *montanum*, 114. *b.*
Coro-ſhut marle, 54. *b.*
Corpora peregrina, impregnated with pit-coal, 904. *a.* *petroleo*, ceu *aſphalto*, *ibid. c.* *pyritaceo*, ibid. *c.*
Coruſcation *(eclair)*, of Metals, 155. *c.* n.
Cos Turcica, 216. *b.*
Countries, in Mineralogy, 2. *c.*
Craie de Champagne, 77. *b.*
Crawford's doctrine of combuſtion, 439. *b.*
Cremor Calcis, 31. *a.* n.
Creta alba, & *friabilis*, 21. *a.* *indurata*, 22. *b.* *granulated*, 23. *b.* *Spathoſa*, 24. *b.*
Creta Brianzonica, 103. *c.*
Cryſtal, (rock) 168. *b.*
Cryſtallization of gems, 164. *b.* n.
Cryſtals, (artificial) by Achard, Bergman, 222. *c.* n. 223. *b.* n. and by Morveau. *Addit.* to pag. 223.
Cryſtals, (pebble, milk) 173.
Cryſtallus montana, 168. *b.*
Cubic nitre, 355. *b.*
Cubit (Egyptian), 148. *b.* n.
Culm coal, 477. *a.*
Cupri (mineræ) Calciformes, 959. *a.*
Pyritaceæ, 960. *b.*
Cuprum Salitum, 403. *a.*

D.

Daze, 106. *c.*
Dephlogiſticated air, 435. *b.* *See* Vital air.
Derbyſhire Spar. 26. *b.* n.
Deſtruction that acts *privative*, 6. *c.* n.
Detonation of Nitre, 347. *c* n.
Detonation of two airs, 445. *c.*
Diamantine Spars. *See Addition* to p. 133.
Diamond, 123. *a.* How and where found, 123, 124, and 128 *c.* n.
Diamonds how valued, 129. *b.* n.

Diamonds, the moſt extraordinary, 130. *b.* n.
Cubic Diamonds, *Addit. to pag.* 125.
Are a coagulated phlogiſtigiſton, 132. *b.* n.
Oriental and *Occidental*, are falſe diſtinctions, 125. *c.* n.
Coloured diamonds, 126. *b.* n.
Their decompoſition, 127, *c.* n. and 132. *c* n.
Obſervations on diamonds, 127. *a.*
Diamond-earth, 15. *c.* n.
Diaſpro, 192. *c.*
Diaſpro roſſo, 193. *b.*
florido, *ibid.*
Brecciato, 890. *a.*
Digeſtive ſalt, 349. *a.*
Diphryges, 790. *b.* n.
Domitian gem, 146. *b.* n.
Drake, or Druſe-hol, 27. *c.* n.
Drop-ſtone, 29. *b.*
Druſe, or *Druſicum*, 28. *c.* n. 59. *a.*
Druſen, 28. *c.* n.
Drying oil, 649. *b.* n.
Dubbleſten, *Doppleſtein*, 26. *a.*
Duckſtein, 53. *a.*—77. *a.*

E.

Earths, how many? 13. *a.* n.
——— what? 9. *c.*
——— Primitive, 13. *b.* n.
——— Derivative, *ibid.*
The 5 original earths, 14. *b.* n.
Earths, Argillaceous, 226. *a.*
——— Calcareous, 15. *a.*
Earths, Ponderous, 84. *a.*
——— Magneſian, or Muriatic, 93. *a.*
——— Siliceous, 120. *a.*
——— (infuſible) 941. *c.* n.
——— which change their colour with fire, 943. *c.* n.
——— diviſible, or not, 945. *c.* n.
——— fuſible, 943. *c.* n
——— ſoluble in borax, 946. *b.* n.
——— in Microſcomic ſalt, *ibid.*
——— ſoluble in ſal ſoda, 944. *c.* n.
——— with efferveſcence, 944. and following, *n.* without it, *ibid.*
Earthy neutral ſalts, 377. *a.*
Eiſen, 713. *a.*
Eiſen bluth, 730. *b.* n.
Eiſenram, 725. *b.*
Elaſtic marble. *See additions* to page 893.
——— ſand-ſtone, *ibid.*
——— petrol, 469. *a.*
Electricity cannot paſs in a perfect *vacuum*, 610. *b*, n.
Electrum, 460. *a.*
Emerald, 146. *a.*
Empyreal air, 437. *c.* n.
Enhydre, 182. *c.* n.
Epſom ſalt, 96. *a.* 97. *a.*
Epſom ſalt with copperas, 421.
Erdepeche, 468. *a.*
Erhartete, 471. *c.*
Etain, 618. *a.*
Expanſion of metals (Table of the), 716. *b.* n.

F.

Fahl-ertz, 559. *b.*
Falling-ſtars, 443. *b.*
Federertz, 557. *b.*
Felt ſpar, 198. 198. *a.* n.
——— Its contents, *ibid.* 198. n.
What it means, *ibid. c.* n.
Fer, 713. *a.*
Ferri (minera) alba, 57. *b.*
Ferrum, 713. *a.*
Fer-blanc, how made? 640 and 641, *c.* n.
Flag-ſtone, 78. *a.* 260. *a.*
Fetid-ſtone, 49. *b.*
Fleſh-coloured Tungſtein, 79. *b.*
Flint, 174. *a.*
Common flint, 189. *a.*
Flint-glaſs, 667. *c.* n.
Flitſmalm, 241. *a.*
Flos ferri, 730. *b.* n.
Flowers of Zinz, 785. *c.* n.
Fluor acid, 295. *a.*
———, Its properties, *ib.*
Singular phenomenon of it, 296. *c.* n. See alſo *Add.* to page 42.
Fluor Spatoſus, 40. *a.*—*induratus*, 42. *c.*
——— 43. *a.*—*cryſtalliſatus*, *ibid. c.*
Fluors, obſervations on them, 44. *c.*—Blue and green, 79. *a.*
———, ſingular form of their fuſion with gypſum. *See Addition* to page 42.
———, it does not produce ſiliceous earth, as Scheele pretended, 45. *c.* n.
Flux, new one, of Dijon, 575. *b.* n.
Foliaceous ſilver ore, 565. *b.*
Foſſil alkali, 333. *b.*
Foſſil-coals (obſervations on), 485. *c.*
Foſſil-pitch, 471. *c.*
Foſſil-wood, 473. *a.*
Fraxinella's vapour is inflammable, 447. *c.* n.
Fromond imitated, in glaſs, the double refracting ſpar, 26. *b.* n.
Fuller's earth, 237. *a.* n.
———, its varieties, 238. *b.* n.
Fulminating gold, 530. *b.*
Fulminating-powder, 495. *b.* n.

G.

Gagas, 473. *a.* 904. *b.*
Galena, 660. *c.*
Galinaceous (lapis), 473. *a.* 916. *b.* n.
Galitzenſtein, See *Vitriolated zinc*, 786. *a.*
Geanthrax, 483. *b.*
Gema divi Stephani, 187. *c.*
Gems (obſervations on), 161. *a.*
Gems (falſe), 169. *c.* n. and 170. *b.* n.
Geſtellſtein, 875. *b.*
Geyſer, ſpout of hot water, 223. *b.* n.
Giacinto guarnacino, 153. *b.*
Giallo de Sienna (marble) 65. *c.* *Antico*, *ibid.*
Gilf, 561. *c.* n.
Giraſole, 178. *c.* n.
Glacies Mariæ, 36. *a.*
Glanz blende, 783. *a.*
Glanz kobolt, 832. *a.* & 827.

Glaſs-

Glaſs-gall, 191. *c.*
Galena, 561. *a.*
Glimmer, 106. *c.* 108. *a.*
Obſervations on it, 110 *b.*
Glauber's Salt, 353. *b.*
Gliſt. 106. *c.*
Gneis, 104. *c.* n. 630. *b.* n.
Gold, its properties, 512. *a.*
——, its ductility, 513. *a.* n.
——, what, if acted on by electricity? 515. *a.* and in the note, *ibid.*
——, its agents, 517. and in the Note.
Gold, native, 520. *a.*
—— mineralized, 524. *a.*
——, obſervations on it, and its mineralizations, 528. *a.* and 533. *b.*
——, its yellow and green colours, 516. *b.* n.
——, how coloured, 520. *b.* n.
—— (fulminating) 530. *b.*
Gold coins alloy, 520. *b.* n.
Monied gold in France, how much, 532. *b.*
Gold naturally amalgamated with mercury, 590. *a.*
Pretended gold in the aſhes of vegetables, 581. *b.* n.
Gorſten, 65. *a.*
Garnet kind, 202. *b.*
Common martialis, 204. *a.*
Obſervations on the garnet, ſhoerl, and cockle, 212. *b.*
Garnets, how to be tried, 213. *c.* n.
Garnet gem (*granatus gema*), 205. *a.*—152. *b.*
Garnet Syrian, 153.
—— *Soranus*, 153. *b.*
Graberg, 72. *c.*—199. *b.* n
Granat-berg, 204. *b.*
Granated (*terræ*), 202. *a.*
Granatſtein, 204. *b.*
Granatus martialis, 204. *a.*
——— *crocis Martis & Jovis*, 206. *b.*
——— *Id. Martis & Saturni*, 207. *a.*
Granitello, 875. *b.*
Granites, 885. *c.*
Granitone, 887. *c.* n.
Greonſten, 885. *a.*
Grey marble, 78. *c.*
Grid-iron pendulums, 715. *b.*
Grignard gypſum, 37. *c.*
Griotte-marble, 81. *c.*
Grit (Argillaceous), 260. *c.*
Grit-ſtone, 895. *c.* n.
Growan, 630. *b.* n.
Guhr, 21. *c.* n.—34. *a.* (or *Lac Lunæ*) 231. *b.*—232. *c.* n.
Gun-powder, 495. *b.* n.
Guneche, 177. *c.*
Gyps Sinter, 37. *b.*
Gypſum, its varities, &c. 32. *a.* and following.
The formation of *gypſum*, 70.
Gypſum micaceum, 35. *a.*
——— *fibroſum*, 35. *b.*
phoſphoricum, 88. *a.*

H.

Hæmatites, 724. *b.* Black, 727. *b.*
——— Red, 728. *a.* Yellow, *ibid. c.*
——— Heterogeneous, 729. *a.*
Hammites,

Hammites, 30. *c.* n.
Halinitrum, 368, *c.*
Halotrichium, 410. *b.*
Hardened Rock-oil, 471, *c.*
Hardneſs (table of the) of various ſubſtances, 225.
Hazel Rod, 898. *b.*
Heat, 436. *c.*
Heliotrope, 193, *a.*
Heliotropium, (Tincture of, 277. *a.* n.
Hepatic Air, its properties, Sect. 230. p. 448. and *foll.*
Homber's Phoſphorous, 17. *c.* n.
Horn blende, 242. *a.*
Hornberg, 109 *c.*
Horn-ſilver ore, 563. *a.*
Humus ater, 263. *b.* 269. *c.* 503. *c* 908. *b.*
Humus conchaceous, 63. *c.* 900. *b.* 907.
——— *Lacuſtris*, 908. *b.*
——— *Vegetabilis*, 907. *c.*
Hyacinth, 149. *a.* 205. *b.*
Hydrargirum, 577. *a.*
——————— *nativum*, 586. *a.*
——————— *Auro vel argento adunatum*, 590. *a.*
Hydrophanes, 178. *a.*

I.

Jacinta la bella, 150, *c.*
Jack-lanthorns, 443. *b.*
Jade, 176. *b.*
Jargon, 132, *b.* & *c.* n.
Jaſpachates, 176. *b.*
Jaſper, 192. *c.*
——— *Fiorito*, 193. *b.*
——— *martialis*, 194. *a.*
Jaſper, 15 varieties of it, 196. *b.* n.
——— *Gramatique*, 196. *c.* n.
——— *Polygrammatique*, 196. *b.* n.
——— Agatiſed, 197. *c.* n.
——— Obſervations on it, 195. *a.*
Jayet, 473. *a.*
Iceland Agate, 917. *a.*
Iceland's volcanic exploſions in 1783. *Addit.* to page 910.
Jern, 713, *a.*
Jet, 473. *a.*
Ignis fatuus, 443. *b.*
Incombuſtible cloth (of Aſbeſtus), 117. *c.* n.
Inflammable Air, its properties. Sect. 229. p. 441, and foll.
——————— its various kinds, 447. *c.* n.
——————— a new one diſcovered by Volta, 442. *c.* n.
——————— water produced by deflagration, 444. *a.*
Inflammables, 10. *a.*—433. *a.*
Infuſible earths, when alone, 941. *a.*
Ink (common), for writing, 405. *b.* n.
Ink-ſtones, 406. *b.* n.
Iris ſtone, 183. *c.*—178. *c.* n.
Iron. Its properties, 713. *a.*
——— Native, 720. *a.*
——— Calciform, 722. *a.*
——— Aerated, 406. *a.*
——— Indurated, 724. *b.*
——— Mineraliſed, 736. *b.* 740. *b.*
——— Refractory, 738. *b.*

Red grained, 739. *b.* Observations on iron, 743. *b.* Method of ſmelting it, 745. *b.* n. *Addit. to page* 78. New method of H. Cort, 748. *c.* and *ſol.* Steel how made, 751. *b.* n. Caſt ſteel invented by Waller, 752. *c.* n. Tempering iron, 753. *c.* n. and *ſeq.* its value exceeds ſometimes manifoldly that of gold, 755. *b.* n. Antimony of ſulphur hinders attraction to the magnet, 756. *c.* Expanſion of ſteel, and of other ſubſtances, by heat, 716. *b.* n. Dephlogiſticated iron has no binding power, 731. *b.* n. Beſt iron ores, 744. *b.* n. Cryſtallized iron, 737. *b.* n. Colours exhibited by heat, 753. *b.* n. Cementing iron-ore, 734. *a.*

Iron. *Minera refractoria* of it, 738. *c.*

—— gives various colours to ſtones, 163. *c.* n.

—— ores aſſayed by the Blow-Pipe, 962. *b.*

Iceland-ſpar, 26. *a.*

Juan blanco, 497. *c.* n.

Juden pech, 471. *c.*

Jupiter, 618.

K.

Kalckartrige erden, 15. *a.*

Kalk-jord, 15. *a.*

Kanel-coal, 480. *a.*

Kaolin, 232. *b.*

Kedria terreſtris, 468. *a.*

Keiſe, 15. *a.*

Keſſekil, 99. *b.*—236. *b.*

Kieſel, 189. *c.*

Kilkenny-coal, 480. *a.*—481. *b.*

Killas, 261. *b.*

Kifter, 31. *b.* n.

Kolm, 477. *a.*

Kolmord marble, 80. *b.*

Krita, 15. *a.*

Kugelertz, 560. *c.*

Kupfernickle, 841. *c.*

L.

Labora, 218. *a.*

Labrador-ſtone, 199. *a.*

Lac lunæ, 20. *a* —231. *b.*

Lacuſtris iron-ore, 732. *b.* n.

Lapis Alabandicus, 154. *a.*

—— *A menus*, 60. *c.*—685. *c.*

—— *Bononienſis*, 88. *a.*

—— *Calaminaris*, 775. *a.*

—— *Calcareous*, 22. *b.*

—— *Corneus*, 189. *c.*—207. *c.*

—— *Corneous Cryſtallijatus*, 207. *c.*

—— *Crucifer*, 212. *a.*

—— *Electricus*, 154. *b.*

—— *Gallinaceous*, 473. *a.*—916. *b.* n.

—— *Hepaticus*, 91. *a.*—93. *c.* n.—475. *c.*

—— *Lazuli*, 247. *a.*

—— *Lydius*, 882. *c*—883. *c.* n.

—— *Molaris Rhenanus*, 917. *c.*

—— *Nephriticus*, 176. *b.*

—— *Obſidianus*, 473. *a.*—916. *b.* n.

Lapis

Lapis Ollaris, 234. *b.*
—— *Spatoſus*, 24. *b.*
—— *Suillus*, 49. *b.*—475. *a.*
Larvæ calcareæ & cretaceæ, 900. *a.*
—— *Spatoſæ*, 901. *a.*
—— *Silicieæ & argillaceæ*, 902. *b.*
—— *Inſalitæ & phlogiſticæ*, 903. *a. c.*
—— *Pyritaceæ* and *metalliferæ*, 904.
—— *Argentiferæ & Cupriferæ*, 905.
—— *Terriferæ & ſulphure confertæ*, 906. & 907.
—— *Hematiticæ*. ibid.
Lavas (volcanic), 909. *a.*
——, antiquity of their layers, 921. *b.* n.
——, compact and vitreous, 922. *c.* n.
——, their component parts, 923. *b.* n.
Lead, its properties, 644. and *following*.
——, its ſucceſſion of colours, 650. *a.* n.
——, Native, 651. *a.*
——, Calciform, 652. *c.*
——, Mixt, 656. *a.*
——, Mineralized, 658. *a.*
——, by the phoſphoric acid, 659. *b.*
——, with ſilver, 660. *c.*
——, with antimony and ſilver, 664. *a.*
——, its ſandy ore, 665. *b.*
——, weight of its mixtures, 625. *c.* n.
Lead, a mixture of it that melts before water boils, 649, *b.* n.
——, obſervations on, 666. *a.*
——, how made into ſheets, 668. *n.*
——, its granulation, 640. *c.* n.
——, how made into ſhot, 669. *b.* n.
——, is very noxious to animals, 670. *b.* n.
——, its danger in four wines, 671. How diſcovered, *ibid.*
Lebererʒ, 557. *b.*
Leberſtein, 91. *b.*
Lemnia (terra), 236. *c.*—Light, 436. *c*,
Limſten, 24. *b.*
Liquor probatorius vini, 671. *b.* n.
Lithanthrax, 476. *a.*
Litharge, 645. *b.*
Lithomarga, 235. *a.*
Litmus (or *Lackmus*), its tincture, 989. *a.*—277. *a.* n. Its *ſuccedaneum*, ib. *c.*
Liver-ſtone, 92. *b.* n.—475. *c.*
Looking-glaſſes how made, 608. *b.* n.
Ludus Helmontii, 888. *b.* n.
Lumachella, 889. *b.*
Lupus Jovis, 866. *b.* n.

M.

Macigno, 82. *b.*
Magneſia alba, 93. *a.*—940. *c.* n.
———— to purify it, 94. *b.* n.

Magneſia alba, with acids, 97. *a.*
——— with other earths, 98. *a.*
——— aerated, 388. *b.*
——— nitrated, 386 *b.*
——— *Salita*, 387. *b.*
——— vitriolated, 384.
——— its compounds, 118. & 119.
Magneſian copperas, 421. *b.*
Magneſian earth (its properties) 940. *c.* n.
Magneſian ſpar, 215. *c.*
Magnetical attraction, 737. *c.* n.
Malachites, 61. *b.*—682. *b.* n.
Maliha, 468. *a.*
Manganeſe, *Manganeſium*,
———, its properties, 848. *b.*
———, is a true ſemimetal, *ibid. c.* n.
———, is magnetical when powdered, 849. *c.* n.
———, Native, 852. *a.*
Native calces of it, 854. *b.*
If well phlogiſticated turns white, 854. *c.* n.
———, white and red, 855. *a.*
———, black, 857. *b.*
———, it is the *Perigord ſtone*, 858. *c.* n.
———, in the *Black wadd*, 859. *b.*
———, in vegetables, *ibid.*
———, Obſervations on it, 860. *b.*
———, is contained in many iron ores, 861. *c.* n.
Manganeſium Salitum, 414. *a.*
Marbles, 65. *c.*
Italian marbles, *ibid.* and *following.*
Cautions on *Collections* or *ſtudii* of marbles from Italy, 69.
Marcaſita officinalis, 757. *a.*
Marcaſites, 498. *c.* n.
Marcaſitical copper ore, 499. *a.*
Marchaſitical gold-ore, 525. *b.*
Marle, *Marga*, 50. *c.*
Marle and arable land, 53. *c.*
varieties of marl, 54. *b.*
Marmor metallicum, 88. *a.*
——— *druſicum*, 89.
Marn, 50. *c.*
Mars (iron), 713. *a.*
Martial (green) vitriol, 404. *a.*
Martial muriatic ſpar, 215. *c.*
Martial pyrites, 406. *b.* n.—740. *b.*
Maſſicot, 646. *b.* n.
Meerſhaum, 99. *b.*
Melites, 193. *c.*
Melons of Mount Carmel, 5. *b.*
Memphites, 184. *a.*
Mercury. See Quickſilver, 577. *a.*
———, its ſpecific gravities, 612. and following, *n.*
———, miſtake of Boerhaave on it, 614. *b.*
———, blunders in barometical obſervations, 616. *c.* n.
——— is not contained in lead, 592. *b.* n.
——— why it feels cold, 609. *b.* n.

Mercury ſublimate corroſive, its great efficacy. 611. *b.*
Metallic expanſions by heat, 716. *b.* n.
Metallic compound which melts before water boils, 649. *c* n.
Metallic ſalts, 400. *a.*
Obſervations on them, 415. *a.*
Metallic ſubſtances, their general properties, 506. *a.*
Metals, 11. *a.*
———, their cryſtallization, 510. *b.* n.
———, their melting heat, 508. *b.* n.
———, table of theſe heats, 509. n.
———, their calcination, 511. *c.* n.
———, the new doctrine about it, *ibid.*
Metals found alſo in lavas, 910. *b.* n.
Mica alba, or Muſcovy glaſs, *Mica lamellis parallelis*, 108. *a.*
—— *ſquamoſa*, } *ibid.*
—— *aceroſa*, }
—— *contorta*, }
Martialis colorata, 109. *a.*
———— *druſica.*
———— *black.*
———— *green.*
———— *druſa.*
Obſervations, 110. *b.*
Artificial mica, 112. *c.* n.
Microcoſmic ſalt, 946. *a.* n.
Mild vegetable alkali. 351. *b.*
Milk-cryſtals, 173. *b.*
Mineral agaric, 20. *a.*
Mineral alkali, 333. *a.*
Mineral tallow, 455. *a.*
Minerals, their formation, 1. *b.*
———, their growth, 3. *b.*
———, by precipitation, 6. *c.*
———, by ſubterranean fires, 7. *a.*
———, by privative deſtruction, 6. *c.* n.
———, their general diviſion, 9. *c.*
Mineralizers of metals, 511. *b.* n.
Minerallized metals, *viz.*
Their habitudes in the fire, 965. *c.* n.
Mineræ arenaceæ, 895. *a.* 896. *c.* n.
——— *Phlogiſticæ Cupri, ferri*, &c. 501.
Minium how made, 645. n.
Mirabile (ſal) glauberi, 353. *b.*
Miſpickel, 741. *a.*
Mocha-ſtone, 185. *c.*—187. *b.*
Mock-lead, 499. *b.*—779. *a.*
Molybdene, its properties, 863. *a.*
———, how diſtinguiſhed from plumbago, 863. *b.* n.
Molybdenic acid. Its properties, 301. *a.*
——— different from the Volfranic or Funyſtemic acid, 304. *c.* n.
Moon-ſtone, 183. *c.*
Moor-ſtone, 885. *c.* n.
Mould, 907. *c.*
Mumia, 455. *a.*—472. *b.*

Mumia vegetablis, 904. *b.*
Muria Chryſolampis, 40. *a.*
Muriatic acid, 290. *a.*
Its properties, *ibid.*
Its ſaturations, 292. *b.* n.
Muriatic barytes, 382. *c.*
——— chalk, 380. *c.*
——— earth, *Terra muriatica*, 93. *a.*
——— copper, 403. *a.*
——— magneſia, 387. *b.*
——— manganeſe, 414. *a.*
——— ſpar, 215. *c.*
Murkſtein, 876. *c.*
Muſcovitiicum (vitrum), 108. *a.*
Muſcovy glaſs, 113. *a.*

N.

Naphta, 465. *a.*
Natron, 367. *a.*
Negrillo, 559. *c.* n.
Nephriticus, (*Lapis*), 102. *b.*
Nero ai Fiandra (marble), 65. *c.*
Nero di Prato, 106. *b.*
Neronian gem, 146. *b.* n.
Neutral ſalts, 340. *a.*
Obſervations on them, 375. *b.*
Nickel. *Niccolum.* 837. *b.* 965. *b.*
———, attracts iron, 838. *c.* n. 840. *c.* n.
——— native, 840. *b.*
——— calciform, 841. *a.*
——— vitriolated, 842. *b.*
——— obſervations on it, 843. *a.*
——— is a true ſemi-metal, *ſui generis*, 848.
Nihil, 785. *c.* 790. *b.* n.
Nihil album, ibid.
Nitre (common), 344. *a.*
——— native is found in Naples. See *Addition to* page 346.
Nitre (cubic), 355. *b.*
Nitre of lime. *Calx nitrata*, 378. *a.*
Nitrated magneſia, 386. *b.*
Nitrous acid, its properties, 284. *a.*
——— pretended formation of it, 286. *b.* n.
——— does not diſſolve gold, 289. *c.* n.
——— its ſaturation by metals and earths, 289. *b.* n.
——— ammoniac, 371. *a.*
Noble and perfect metals, 512. *a.*

O.

Oculus Mundi, 178. *a.*
Obſervations on it, 180. *a.*
Ofenbruch, 789. *c.* n.
Ollaris (lapis), 104. *b.*
Onychites, 790. *b.* n.
Onix camehuja, 184. *a.*
Oölithas, 30. *a.*—76. *c.*
Opal, 157. *b.*
——, artificial, 161. *b.* n.
Oriental and *occidental* denominations of gems, are arbitrary, 125. *c.* n.
Orpiment, 816. *b.*
——— probatory liquor made by it, 822. *c.* n.
——— how it may be ineffectual, 823. *b.* n.
Oſmundian argilla, 237. *c.* n.

Oſteocolla,

Oſteocola, 77. *a.*
Oxygine (oxigene) principle, 435. *b.* n.

P.

Paedros, 157. *b.*
Panormitana (*calx nativa*), 20. *b.*
Paper-marle, 54. *b.*
Paragone antico, 193. *b.*—196. *c.* n.
Parget, 32. *a.*
Parian-marble, 68. *b.*
Pavonium, 196. *b.* n.
Pearl ſlag, 918. *b.*
Peat, 483. *b.*
Pebbles, 189. *b.*
Pebble-cryſtals, 173. *b.*
Pechblende, 569. *b.*
Peridot (is the chryſolite), 142. *c.* n.
Perigord ſtone, 858. *b.* n.
Peru emerald, 145. *b.* n.
Petrefactions, 873. *a.*
Petrefacta, or *Petrifications*, 898. *c.*
Petrefacta Calcarea, 900. *b.* *Spatoſa*, 901. *a.* *Silicea*, 902. *a.* *Inſulita*, 903. *a.*
Petrefacta Lithantracea, 904. *a.*
——— *Petroleo*, ceu aſphalto impregnata, 904. *a.*
——— *Pyritacea*, ibid. *c.*
——— *Argentifera*, 905 *b.*
——— *Cuprifera*, ibid. *c.*
——— *ferrifera*, 906. *c.*
Petroſilex, 189. *b.*
Petrol (*Petroleum*), 467. *a.* Elaſtic petrol, 469. *a.*
Petroleum tenax, 468. *a.*
——— *induratum*, 471. *c.*
Petuntſe, 198. *a.*
Pewter, 642. *b.* n. It is generally miſtaken abroad, and called *tin*, or *etain*, 643. *b.* n.
Phlogiſta mineralia, 433. *a.*
Phlogiſton, 436. *a.* n.—441. *c.* n.
——— Its exiſtence, 442. *b.* n. *Addit. to page* 445.
——— with aerial acid, 452. *b.* n.
——— with earths, 475. *a.*
Phoſphorus of Kunkel; how to make it, 311. *b.* n.
———, how made its acid in a fluid form? 313. *c.* n.
——— precipitates metals from their ſolutions, 314. *c.* n.
Phoſphoric acid. Its properties, 310. *a.*
Phoſphoric appearance in the barometer, 610. *a.*
Phoſphorus nativus, 88. *a.*
Piedra d'el Ynca, 497. *b.*
Pierre de St. Ambroix, 83. *a.*
Pietra Columbina, 82. *a.*
Pietra Columbina Bigia, ibid.
Pip-lera, 240. *c.* n.
Pipe-clay, 234. *a.*
Piſolithes, 30. *a.*—76. *c.*
Pit-coal, 476. *a.*
Pitch-blende, 780. *a.*
Pitch (foſſil), 471. *c.*
Pix montana, 471. *c.*
———, *impure*, 472. *b.*
Placites, 790. *b.* n.
Plaſter, its contents, 32. *c.* n.
Plaſter-ſtone, 32. *a.*

Platine. *Platinum.* Its properties. 567.
——— how rendered malleable, 574. *a.* n.
——— method of Mr. Achard, 576. *b.* n.
——— Its ſpecific gravities, 571. *b.* n.
Plumbago, its properties, 451. *a.*
Plumbago of iron, 453. *c.* n.
Plumbum, 644. *a.*
Plumbum uſtum, 645. *b.* n.
Pocket Laboratory (The Dry) 929. *b.* 977.
——— (The Humid), 988. *b.*
——— (The Lamp Furnace), 991. *c.*
Polarity of attraction, 429. *c.* n.
Poles (falſe) of electricity, 155. *b.* n.
Pompholix, 790. *b.* n.
Ponderous earth, 84. *a.*—940. *b.* n.
——— ſpar, 85. *c.* n.
——— aerated, 87. *a.*
——— druſen, 89. *b.*
——— *vitriolata*, 382. *a.*
Ponderous earth (its properties), 940. *b.* n.
Pont-marle, 54. *b.*
Porcelain earth, 103. *b.*—232. *b.*
Porfiao, 879. *a.*
Pori, 77. *a.*
Porphyry, (calcareous) 83. *a.*
Porphyry, 879. *a.*
Porphyrites, 879. *a.*
Portland-ſtone, 78. *a.*
Potters lead-ore, 499. *b.*
Potter's ore, 661. *c.* n.
Potzevera, 166. *a.*
Praſe, 144. *c.* n.
Precious ſtones falſely called *Oriental* or *occidental*, 125. *c.* n.
Precious ſtones (obſervations on), 161. *a.*
Precious ſtones analyzed, 165. *b.* n.
Prince's metal, 708. *b.*
Probatory liquor of orpiment, 822. *c.* n.
Pruſian blue, native, 733. *a.*
Pſeudo-agate, 159. *c.* n.
Pſeudo-galena, 778. *b.* n.—*Pſeudopalus*, 177. *b.*
Pudding-ſtone, 82. *b.*
Pulvis pyrophorus, 397. *b.*
Pumice ſtone (*pumex*), 917. *c.*
Purbeck ſtone, 78. *a.*
Putty, 643. *c.* n.
Puzzolana, 72. *b.*
Pyritaceous lime-ſtone, 83. *a.*
Pyrites ſubflavus, 497. *b.*
——— *rubeſcens*, 498. *a.*
Pyritical gold-ore, 499. *c.*
Pyrometer of Wedgwood, 228. *a.* n.
Pyromachus, 189. *a.*
Pyrophorus, 283. *b.*—397. *c.* n.

Q.

Quartz, 165. *a.*
——— rock cryſtal, 168. *b.* and 172. *a.*
——— heterogeneous, 171. *a.*
——— its ſeven ſpecies, 174. *b.* n.
——— obſervations, 172. *b.*

Quartz, rombic, 198. *a.*
Quickſilver. Its properties, 577. *a.*
———— is a perfect metal, 579. *b. n.*
————, its ſpecific gravities, 612. *a.* n.
———— Native, 586. *a.*
———— united to gold and ſilver, 590. *a.*
———— mineraliſed, 593.
———— Cinnabar (pure), 593. *a.*
————, Cinnabar (impure), 596. *a.*
————, with iron and ſulphur, 597. *b.* n.
————, with marine and vitriolic acids, 602. *a.*
———— reduced into vapours, 579. *c.* n.
————, red precipitate, 583. *b.* n.
————, mines of, 586. *c.* n.
———— Turbith mineral, *ibid. c.* n.
————, *Æthiops perſe*, 579. *a.* n.—585. *b.* n.
————, precipitate *perſe*, 578. *c.* n.
———— Pyritous cinnabar, 597. *c.*
———— Pyritous mercurial ores, 600. *a.*
————, obſervations on, 603. *a.*
————, its amalgamations, 606. *b.* n.
———— is the moſt effective medicine, 611. n.

R.

Ragg-ſtone, 217. a.
Rainbow-ſtone, 183. *b.*
Rapakivi, 887. *c.* n.
Rauch Topaz, 169. *b.*
Red cabbage inſtead of *Litmus*, 277. *b.*
Red-lead how made, 645. *b.* n.—646. *b.* n.
Refraction (double) of the Iſlandic ſpar, 26. *a.*
————, imitated in glaſs by Fromond, 26. *b.* n.
Reiſbley, 451. *a.*
Rheniſh mill-ſtone, 917. *b.*
Rock-cryſtal. See Quartz.
Rock-oil, 465. *a.*
Hardned rock-oil, 471. *c.*
———— How found, 466. *b.* n.
Rhombic quartz, 198. *a.*
Rotten-ſtone, 253. *c.* n.
Rothgulden, 551. *b.*
Rowley rag, 215. *a.*
Rubble-ſtone, 65. *a.*
Rubicell, 136. *a.*
Rubino di Rocca, or *Rubinus rupium*, 136. *c.* n.—153. *b.*
Ruby, 134. *a.*
————, how made by art, 136. *b.* n.
————, mother of, 136. *a.*
Ruſſigtes-ertz, 553. *c.*

S.

Sädig, 725. *b.*
Sal ammoniacum fixum, 17. *b.* 39. *a.*
———— native ammonial, 372. *b.*
Sal fontanum, 361. *a.*
Sea Salt, (common), 357. *b.*
Sal gemmæ, 359. *b.*
Sal marinum, 360, *a.*
Sal montanum, 358. *a.*

Sal

Sal mirabile glauberi, 353. *b.* 336. *b.*
Sales medii Metallici, 400. *a.*
—— obſervations on them, 415. *a.*
Salpetre, 344. *a.*
Salt (common) with magneſia, 420. *b.*
Saltaſka, 39. *a.*
Salts, 10. *a.* 272. *a.*
—— are they reducible to one another? 286. *a.* n. 275. *b.* n.
—— obſervations on ſalts, 428. *a.*
—— their incombuſtibility, 430. *c.* n.
—— their formation, 430. *c.* n.
Salts (earthy), 377. *a.*
Salts (metallic), 400. *a.*
Salts (neutral), 340. *a.*
Salts (triple), 417. *a.*
Salt-ſlag, 23. *b.*
Sancti Stephen's Stones, 77. *c.*
Santi Stephani gemma, 187. *c.*
Sand-iron, 730. *c.* n.
Sandiver, what? 191. *c.*
Sand-ſtone, 892. *c.* with various granules, *ibid.*
Sapphire, 137. *a.*
Sapphires better than rubies for jewelling watches, &c. 139. *c.* n.
Sardea, 187. *c.*
Sardonyx, 185. *b.* 186. *c.*
Saturnite, 870. *c.*
Saxa compoſita, 874. *a.*
Saxa conglutinata, ibid. and 888. *a.*
—— obſervations on *Saxa* and Stones, 897. *a.*
Saxum Danemoreuſe, 880. *c.* n.
Saxum Sahlbergenſe, 82. *b.*
Scheele's doctrine of *heat*, *phlogiſton*, and *fire*, 436. *c.* n.
Schiſti, 256. *c.*
Schiſtus Aluminaris, 395. *b.* n.
—— Bituminous, 259. *b.* 479. *c.* n.
—— *Pyritaceous*, 258. *c.*
—— *tegularis*, 257. *c.*
Schoerlus Bergmani, 207. *b.*
—— *cryſtalliſatus*, 211. *b.*
—— *fibrous*, 209. *c.*
—— *ſpatoſus*, 209. *a.*
Schörls, or Shirls, 202. *a.* 207. *b.*
—— ſparry, 209. *c.*
—— are electrical, 155. *c.* n.
Shirl cryſtallized, 211. *b.*
Stangen Shoerl, 211. *c.* n.
—— obſervations on ſhirls, garnets, and cockles, 212. *b.*
Schwach, *Schwartſtein*, 882. *a.*
Schwartſkoil, 882. *a.*
Schwartz guldenertz, 559. *c.* n.
Scoriæ vulcanorum, 909. *a.*
Scotch-coals, 489. *a.*
Sedlitz, or Seydſhutz Salt, 96. *a.*
Selenites, 36. *a.*
Serpentine ſtone, 106. *b.*
—— zoeblitz, 103. *a.*
Serpentino antico, 879. *b.*
Serpentinus (lapis), 101. *a.*
—— obſervations on them, 105. *b.*
Sevum minerale, 455. *a.*
Sexterces, their value, 158. *c.* n.
Sigiliata rubra, 239. *c.* n.
Siderite, 869. *a.*
Silber haltigerkies, 561. *b.*

Silberartiges, 565. *b.*
Silex, 174. *a.*
Siliceous earths, 120. *a.* 941. *b.* n.
——— obſervations on it, 217. *c.*
Siliceous muriatic ſpar, 215. *c.*
Silver, its properties, 535. *a.*
——— the pureſt, 539. *c.* n.
——— native, 540. *b.*
——— united to gold, 543. *a.*
——— naturally alloyed, 543. *a.*
——— mineraliſed, 547. *c.*
——— Arſenico-martial, 550, *a.*
——— red or ruby ſilver ore, 551. *b.*
——— with arſenic and iron, 553. *b.* 556. *a.*
——— with copper and iron, 554. *a.*
——— with lead, 561. *a.*
Silver from lead, 544. *c.* n.
——— Plumoſe, 556. *b.* n. 557. *b.*
——— and covered with mercury, 590. *a.*
——— with copper and antimony. 559. *c.*
Silver is generally contained in lead, but ſeldom in a quantity worth its ſeparation, 544. *c.* n.
——— antimony, 557. *a.*
——— with antimony and barytes, 562. *a.*
——— with cobalt and ſulphur, 558. *a.*
——— with zinc, 560. *b.*
Silver gooſe-dung ore, 564. *b.*
Horn ſilver ore, 563. *a.*
Combuſtible, 562. *c.* 565. *b.*
Obſervations on Silver. 565. *a.*
Silberſchwartz, *Silber mulm*, 553. *b.*
Singel, 189. *b.*
Sinople, 194. *a.* Variagated, *ibid. c.* n.
Sinter, 30. *b.*
Sinter gyps, 37. *b.*
Skiolige, 101. *b.*
Skiorl Spar, 148. *b.*
Slag Sand, 919. *b.*
Obſervations on volcanic ſlags, [illegible] *c.*
Slate, *Schiſtus*, 2[illegible] *c.*
——— *Tegularis*, 257. *a.*
——— *Scriptorius*, 258. *b.*
Slate-coal, 479. *a.*
Smalt, 835. *c.* n.
Smaragdus gemma, 146. *a.*
Smectis, 98. *c.*
Soap-rock, 80. *b.* 100. *b.*
Soap-ſtones, 100. *b. c.* n.
Soil (arable), viz. obſervations on it, 53. *c.*
Soranus (garnet), 153. *b.*
Spar, calcareous, 25. *b.*
——— iſlandic, 26. *a.*
——— imitated in glaſs, 26. *b.* n.
——— its form, 27, *b.* n.
Spar like gypſum, 36. *a.*
Sparry fluor, 40. *a.* 43. *a.*
Obſervations on *fluors*, 44. *c.*
Sparry fluor produces not ſiliceous earth, 45. *c.* n. but corrode glaſs, *ibid.*
Spars (adamantine). *See Addition to page* 133.
Spathum calcareum, 25. *c.*

Spathum

Spathum Rhomboidale, 26. *b.*
Coniformis, 30. *a.*
——— *Islandicum*, 26. *a.*
——— *Lamellosum*, 27. *a.*
Spath crystallen, 28. *a.* *Spath drusen*, ibid.
Spatum, *Scintilans*, 198. *a.*
——— *versicolor*, 199. *a.*
——— white, 200. *b.*
Observations on it, 201. *b.*
Spathig gyps, 84. *b.*
Spathartiger gyps, ibid.
Specific gravities (table of), 225.
* *Specific gravities*, a new balance for this operation, 1007. *a.*
Speculums (metal for), 711. *b.* and *c.* n.
Speiss, 741. *c.* n.
Spelter, 769. *b.*
Spiauter, 769. *b.* 784. *b.* n.
Spinell ruby, 136. *a.*
Spodium, 790. *b.* n.
Spring Sea-salt, 361. *a.*
Spuma lupi, 866. *a.*
Spuma maris, 99. *b.*
Stahlstein, 57. *b.* 729. *a.*
Stahl-stein, 25. *a.*
Stalactites calcareous, 29. *b.*
Stalactites globosus, 29. *c.*
Stalactites coniformis perforatus, 30. *b.*
Stalactites and Stalagmites, 76. *b.*
Stangen Shoerl, 211. *c.* n.
Stannum, 618. *a.*
Stannum corneum, 624. *c.* n.
Steatites, 80. *b.* 100. *b.*
Martialis, 104. *a.*
——— Pure, 209. *a.*
Steel. *See* Iron, 751. *b.* n.
Steel-marle, 54. *b.*
Steinoel, 467. *a.*
Steinpech, 471. *c.*
Stellsten, 875. *b.*
St. Stephen's Stones, 77. *c.*
Stone coal, 476. *a.*
Stone icicle, 29. *b.*
Stone marrow, 235. *a.*
Stone slate marle, 54. *b.*
Stone turf, 484. *b.*
Stony, or sandy ore of Lead, 665. *b.*
Storgrufwa, 24. *b.*
Suber montanum, 115. *a.*
Succinum, 421. *a.* 460. *a.*
Succinum nigrum, 473. *a.*
Succinous acid, its properperties, 318. *a.*
Sulphur, 491. *a.*
Its composition by Stahl, *ibid.* New doctrine on it, 492. *b.* n. and objections, *ibid.*
Sulphur, (native) 493. *c.*
Its liver, 494. *c.* n.
Sulphur metallis saturatum, 497. *a.* 499. *and foll.*
with metallic earths, 501. *a.*
Sulphureous coal, 481. *c.*
Sulphuris magister, 494. *c.* n.
Swampy iron-ore, 732. *b.* n.
Swine spar, 475. *a.* 49. *b.*
Swine stone, 49. *b.*

T.

Table (analytical) of thirteen magnesian compounds, 118 & 119.
*——— of precious Stones, 165. *b.* n.
*——— of various Clays, 238. *c.* n.

*—— of comparative hardneſs and ſpecific gravities, 225.
*—— of various minerals, 225. *a.*
*—— of Wedgwood and Fahrenheit's Thermometers, 230. n.
*—— of metallic expanſions, 716. *b.* n.
*—— of the melting heat, ſpecific gravity, ſaturing phlogiſton, and attraction of it by different metals, 509. *a.* n.
*—— of the ſaturation of *pure vitriolic acid*, with *metals*, alkalis, and earths, 282. *b.* n.
*—— of *pure nitrous acid* with the ſame, 289 & 288. *c.* n.
*—— of *pure muriatic acid* with the ſame, 292. *b. n.*
Talc, or Mica, 108. *a.*
Talcum officinale, 109. *b.*
—— *corneum*, 242. *b.* n.
—— *ſtriatum, nitens*, ibid.
Talchina, (pietro) 80. *c.*
Tallow, (mineral) Sect. 232. p. 455.
Tarninge Spath, 88. *a.*
Tartarus vitriolatus, 283. *b.*
Taub Kohle, 482. *c.*
Tauffſtein, 211. *c.* n.
Telgſten, 104. *b.*
Terra aceldama, 20. *b.* n.
Terra calcarea. See chalk, 15. *a.*
Terra ponderoſa, 84. *a.*
Terra ponderoſa aerata, 87. *a.*
Terra muriatica, 93. *a.*
—— *Porcellanea*, 103. *b.* 232. *b.*
—— *Lemnia*, 236. *c.*
—— *Porcellanea Luneburgica*, 251. *b.*
—— *Tripolitana*, 253. *a.*
Terra pozzolana, 735. *a.* n.
Terra rubrica, 240. *a.*
Terræ larvatæ, 900. *a.*
Terræ ſigillatæ, 240. *c.* n.
Terras, 734. *a.*
Terras, or *Tarras*, for making cement, 71. & 72.
Terre glaiſe, 234. *b.*
Terre noire, 234. *b. verte*, 240. *a.*
Therebinthizuſa, 193. *c.* n.
Thermometer, or Pyrometer, of Wedgwood, 228. *a.* n.
Thermometers, how made? 604. *b.* n.
Tin, its properties, 618. *a.* Nativum, 626. *a.* Calciform, 628. *a.* Cryſtallized, 632. *a.* Obſervations on Tin, 637. *a.*
—— fuming *liquor of Libavius; ſtannum corneum*, 624. *b.* Weights of Tin and Lead mixed together, 625. *c.* n. *Aurum muſivum*, 635. *a.* Obſervations, 637. *b.* Deflagration of Tin with cupreous nitre, 639. *a.* n. 677. *b.* n. Its uſe for looking-glaſſes, 608. *a.* n. This is an old invention, 640. *b.* n. Danger ſtill remaining of tinned copper veſſels, 641. *b.* n.
Tin-plate, how made? 641. *c.* n.
Pewter, 642. *b.* n.

Tin with other metals, 633. *b.*
Tin, does it contain arſenic? 620. *b.*
Tin-glaſs, 757. *a.*
Tingrains, (like garnets), 633. *c.*
Tincal, 364. *b.* n.
Toad-ſtone, 261. *c.*
Tombac, 708. *b.*
Topaz, 139. *a.*
Tophi, 77. *a.* 920. *b.* n.
Tophſtein, 53. *a.*
Torrſten, 739. *c.* n.
Tourmalin, 154. *b.*
Its electricity, 155. *b.* n.
Traaſs, 734. *c.* n.
Trapp, 880. *a.*
Tratſkiol, 882. *a.*
Tree-root changed into clay, 233. *a.* 902. *b.*
Trip, 154. *b.*
Triple Salts, 417. *a.*
Tripoli's ſuppoſed formation, 122. *c.* n. 253. *a.*
Trippel or Tripoli. See this laſt.
Tritura rubra, 739. *b.*
Trough for waſhing the ores, 974. *c.*
Trifa, 920. *b.* n.
Tungſtein, 46. *b.*
——— red, 79. *b.*
——— fleſh-coloured, *ib.*
Tungſtenic or Wolfranic acid, its properties, 304. *b.*
Tung-ſpat, 84. *b.*
Turba, 907. *c.*
Turf, 407. *c.* n. 907. *c.*
Turkina, (*pietra*), 82. *b.*
Turkiſh earth, 237. *b.* n.
Turky Stone, 216. *b.* 878. *b.*
Turquoiſe, 686. *a.*
——— (falſe), 691. *b.*
Tutenago, 776. *c.* 784. *b.* n.
Tutia, or *Tuthia*, 789. *c.* n.

V.

Vegetable alkali, 329. *a.*
Verde di prato, or *di Suza*, 106. *b.*
Verdegris, what? 702. *b.* n.
Vermeille, garnet, 153. *b.*
Violet rays of light part eaſily with phlogiſton, 438. *a.* n.
Virgula divinatoria, 898. *b.*
Vital air for the *Lamp Furnace*, 995. *a.*
Vitriolic acid, its properties, 280. *a.*
——— quantities of metals and earths for its ſaturation, 282. *b.* n.
Vitriolated tartar, 342. *a.*
Vitriolic ammoniac. 369. *a.*
Vitriol of copper, 401. *b.*
Vitriol of iron, (green vitriol), 404. *a.*
Vitriolated nickel, 413. *a.*
Vitriol of Zinc, 411. *a.*
Vitriol of copper and iron, 424. *c.*
Vitriol of copper, iron, and zinc, 425. *a.*
Vitriol of iron and zinc, 426. *a.*
Vitriol of iron and nickel, 427. *a.*
Vitriolic ammoniac, 369. *a.*
Vitriolated barytes, 382. *a.*
Vitriolated magneſia, 384. *b.*
Vitriolated calx, (gypſum), 377. *a.*

Volatil alkali, 337. *a.*
Volatil alkali aerated, 374.
Volcanic explosions in Iceland, in 1783. *Add* to page 910.
Volcanic metals, 910 *b.* n.
Volcanic productions, 909. *c.* and foll.
Vulcanorum Scoriæ, 909. *a.*

W.

Wadd, its properties and uses, 451. *a* 454. *b.* 455. *c.*
Wadd, (black), 859, *b.* n.
Walkera, 236. *b.*
Water, what? according to the new theory, 444. *b.* n. Not produced, but devolved. *Add to page* 445.
Water opal. 183 *b.*
* *Weights*, the nicest and general, how easily made, 1010. *a.*
Weisertz, 556. *a.*
Weises eisen rz, 57. *b.*
Weiss eisen Spath, 729. *b.* n.
Weissgulden, 555. *a.*
Whetstone, 877. *b.*
White copper, 710. *a.* and *c.* n.
White lead, how made, 648. *b.* n.
Wismuth, 757. *a.*
Wolfram, 208. *c.* n. 866. *a.*
Wolfranic, or Tungstanic acid, its properties, 304. *b.*
Wurffel-Spath, 88. *a.*

X.

Xilanthrax, 482. *c.*

Z.

Zaffre, 835. *b.* n.
Zeolite, 244. *a* purus, 246. *c.*
——— Lapis Lazuli, 247. *a.*
——— *Spinosus*, 249. *a.*
——— *Cristallizatus*, 250. *b.*
Observations on Zeolites, 251. *a.*
Found in lavas, 252. *b.* n.
Ziment copper, 5. *a*
Zinc, its general properties, 769. *b.*
——— [illegible]ges copper into go[illegible] colour, 70[illegible]. *c.* [illegible] 710. [illegible] n. 7[illegible]
——— is attrac[illegible] tracts, like the load-stone, 772. *c.* n.
——— becomes electrical by friction, 772. *c.* n.
——— native Zinc, 773. *a*
——— calciform, 774. *a.*
——— *lavis calaminaris*, 775. *a.*
Zinc discovered by Dr. Lawson in England, 785. *c.* n.
——— mineralized Zinc, 775. *c.*
——— zeolythiform, 777. *a.*
——— *Pseudo galena*, 779. *a.*
——— Zinc spat, 782. *c.* n.
——— *glanz blende*, 783. *a.*
——— vitriolated, 784. *a.*
Observations on Zinc, 784. *b.*
——— its smelting, 788. *and foll.* n.
Zinethum, 769, *b.*
Zinn, 613. *a.*
Zeoblitz serpentine, 103. *a.*
Zonites, 790. *b.* n.

THE END.

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